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STUDY OF NAVAIDS REMOTE PERFORMANCE CONTROL AND DISPLAY

PROTOTYPE DESIGN AND OPERATIONAL CHARACTERISTICS FOR DATA LOGGING, DISPLAY AND CONTROL OF A NAFEC TEST MODEL (ILS, VOR, TACAN)

Morris Ritter, et al.

MAY 1977

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16. Abstract

This study paralleling FAA's Maintenance Growth Management concepts presents a standardized and modularized approach for the remoting of certification type data for multiple NAVAIDS (VOR, TACAN, ILS, etc.) to provide ATF status and control at a central location. Growth potential to encompass other NAVAID types (RCAG, ALS, RVR, Beacon/Radar, etc.) may be incorporated in the proposed system, providing the proper interfaces are accomplished.

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SUMMARY

To demonstrate the feasibility of automating NAVAID (VOR, TACAN, ILS) certification data collection and providing status information to a central location, the National Aviation Facilities Experimental Center (NAFEC) has prepared this technical study utilizing a computer controlled data collection, display, and control system. The monitored parameters will, through implementation of this study, be remoted to a central location (NAFEC). Equipment failures as well as prealarm conditions will be immediately indicated at the NAFEC site to demonstrate the feasibility of accomplishing remedial action in a minimum of time.

The system will automatically provide a record of all failure modes as well as all monitored parameters. At each of the field sites, a microprocessor will process the monitored parameters for transmission on demand or at periodic intervals except under alarm or prealarm conditions when priority messages will be transmitted.

1.0 INTRODUCTION

Current FAA field maintenance procedures require that periodically (each week, two weeks, etc.) equipment parameters be recorded for certification purposes. Maintenance personnel can spend several hours in nonproductive time just travelling to and from the remote facilities to obtain routine status information. Additionally, when a system monitor alarms with a resulting shutdown or transfer to standby equipment, no clues are provided to maintenance personnel regarding the cause of the failure because only NORMAL/ABNORMAL status signals are remoted from each site. Thus, several trips may be required between the central maintenance office/lab and the remote site to identify the source of the failure, gather appropriate test equipment, spare boards, etc., and return to the site to repair or replace the failed unit. Logically, a considerable cost saving could be effected by remoting equipment operating parameters to the central maintenance location which would apprise maintenance personnel of an impending failure and provide some diagnostic data in the event of a failure.

The test model (sector), if approved by AAF and AEA, would consist of five VORTAC facilities and one ILS facility. The ILS system is the commissioned facility on Runway 13-31 at NAFEC. The location of the five VORTAC sites are Millville (MIL), Sea Isle (SIE), Woodstown (OOD), Coyle (CYN), and Atlantic City (ACY). These sites are representative of FAA commissioned VORTAC facilities. To prevent any operational disruptions, this proposed system would be installed in parallel with the existing control and display system.

NAFEC's proposed Remote Performance Monitor/Control System (RPMCS) will (1) eliminate the requirement for maintenance personnel to travel to and from remote field sites to perform routine equipment checks for certification purposes; (2) provide maintenance personnel with diagnostic data facilitating the timely repair and restoration to service after a failure; (3) provide prealarm warnings to alert maintenance personnel of possible impending failures; (4) provide a data base for statistical parameters, i.e., MTBF, A, MTTR, etc.; (5) provide protection as appropriate against lightning-induced transients on buried control and status lines; (6) provide a composite control and status display at the central site; (7) provide a hard copy and/or magnetic tape of monitored parameters at desired routine intervals as well as all failure data; (8) provide a test bed for feasibility/operational testing, design changes, evaluation, etc.; and (9) provide the wherewithal to prepare an optimized production specification for a universal remote performance monitoring and control system (RPMCS).

2.0 SYSTEM DESCRIPTION

2.1 General.

Figure 1 represents a typical sector configuration using NAFEC as the central location for the model (VOR, TACAN, ILS). Figure 2 represents the overall system configuration in simplified form. The ILS system at NAFEC and the five remote VORTAC sites will be monitored/controlled at the central control and display position (NAFEC). (Note: Controlled in the sense that NAFEC would perform certain tasks within the experimental equipment. No control of the commissioned facilities would be provided at this time.)

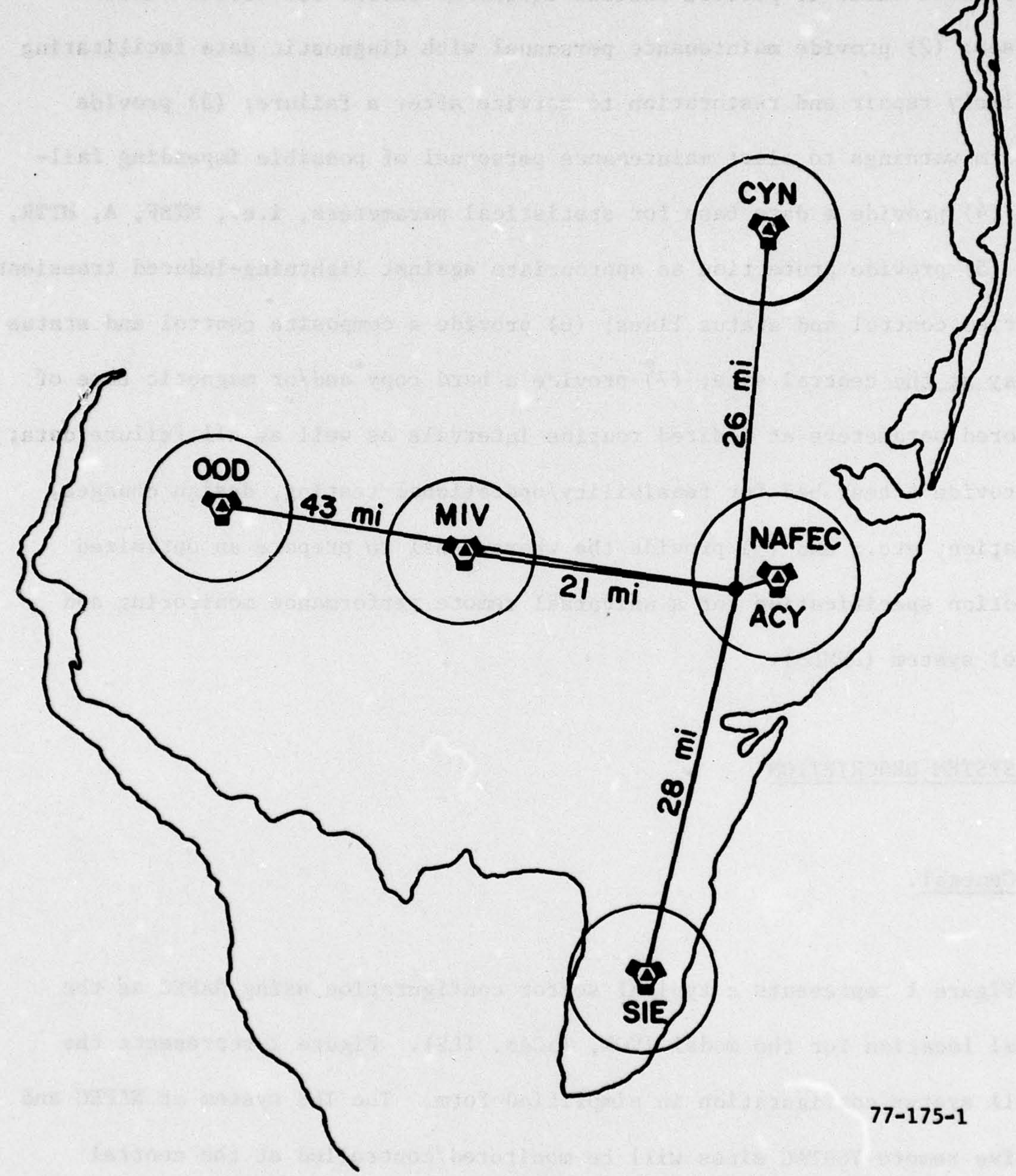

FIGURE 1. TYPICAL SECTOR CONFIGURATION

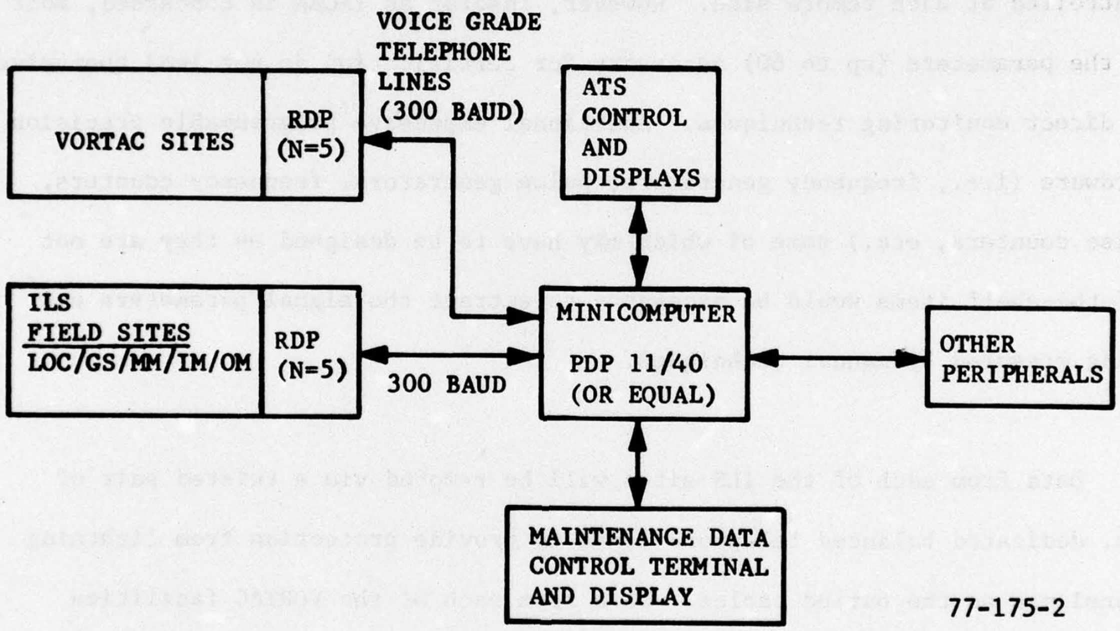

FIGURE 2. SIMPLIFIED EQUIPMENT CONFIGURATION (REMOTE PERFORMANCE MONITOR AND CONTROL SYSTEM)

Up to 64 analog and 16 discrete signals will be monitored/controlled at each ILS localizer and each glide slope site. The ILS marker beacon sites will be monitored for up to eight analog and eight discrete signals. The ILS middle marker site includes a far-field monitor (FFM) and the outer marker site includes a compass locator (LOM).

For VOR-TACAN, up to 96 analog and 48 discrete signals will be monitored/controlled at each remote site. However, insofar as TACAN is concerned, most of the parameters (up to 60) necessary for certification do not lend themselves to direct monitoring techniques. Additional expensive programmable precision hardware (i.e., frequency generators, pulse generators, frequency counters, pulse counters, etc.) some of which may have to be designed as they are not off-the-shelf items would be necessary to extract the signal parameters now being measured by manual techniques.

Data from each of the ILS sites will be remoted via a twisted pair of d.c. dedicated balanced telephone lines to provide protection from lightning transients on the buried cables. Data from each of the VORTAC facilities will be remoted via voice grade telephone lines and dial-up techniques to and from the central location.

To prevent any operational disruptions, this proposed system will be installed in parallel with the existing control and display systems. Parallel operation will be maintained throughout the evaluation period.

2.2 Field Site Configuration.

2.2.1 General.

Figure 3 represents the equipment configuration at each field site; i.e., VOR, TACAN, ILS. At each field site, specified parameters will be measured, compared to a preset limit (prealarms, alarm, etc.) and stored in the RAM for two consective data cycles. The limits will be stored and can be updated through the minicomputer at the central location. Routinely (6-hour period or as selected), all sites will be sampled and data transmitted to the minicomputer for display and printout. Priority messages (failure modes) will be transmitted immediately to the central location and designated display areas.

2.2.2 System Operation.

Signal sources such as monitor test points, RF levels, and discrete levels representing typical certification parameters will be sampled at each site. The parameters selected are based on ILS and VORTAC equipments currently in use by the FAA. Typical parameters are listed in tables 1, 2, 3, 4, 5, and 6. Individual analog and discrete voltages will be signal conditioned by an interface unit, multiplexed, digitized as required, and entered into the microprocessor (figures 4 and 5). Each signal will be compared to preset alarm limits. Should any of the preset alarm limits be exceeded, a priority message will be generated and sent to the central location and designated display areas. The operating program will be stored in an EPROM which is

TABLE 1. TYPICAL PARAMETERS FOR LOCALIZER SITE

Equip. Site	Signal Type	Parameters			
LOCALIZER	ANALOG	1. CLR on CSE RF 1	17. FFM DDM 1	33. CLR Tx 1 Amp I	49. PS Voltage +5
		2. CLR on CSE SDM 1	18. FFM DDM 2	34. CLR Tx 1 18 V	50. PS Voltage +5
		3. CLR on CSE DDM 1	19. CSE(C+SB)P	35. CLR Tx 1 var.vlts	51. PS Voltage -18
		4. CLR on CSE RF 2	20. CSE(SBO)P_o	36. CLR Tx 1 det. RF	52. PS Voltage -18
		5. CLR on CSE SDM 2	21. CLR(C+SB)P_o	37. CSE Tx 2 DBLR I	53. PS Voltage -50
		6. CLR on CSE DDM 2	22. CLR(SBO)P_o	38.	54. PS Voltage -50
		7. CLR off CSE DDM 1	23. Batt chg volt.	39.	55.
		8. CLR off CSE DDM 2	24. Batt chg current	40. Repeat 25 through	56.
		9. Sens DDM 1	25. CSE Tx 1 DBLR I	41. 36 for Tx 2	57.
		10. Sens DDM 2	26. CSE Tx 1 Preamp I	42.	58.
		11. CSE RF 1	27. CSE Amp I	43.	59.
		12. CSE SDM 1	28. CSE 18V	44.	60.
		13. CSE DDM 1	29. CSE var. volts	45.	61.
		14. CSE RF 2	30. CSE det. RF	46.	62.
		15. CSE SDM 2	31. CLR Tx 1 DBLR I	47.	63.
		16. CSE DDM 2	32. CLR Preamp I	48.	64.
	DISCRETE	1. Main On	4. Abn. Monitor	7. Cycle (From Tower)	10.
		2. Stby On	5. Local Control	8. Interlock Control (From Tower)	11.
		3. Transmitter Off	6. Monitor Locally Bypassed	9.	

TABLE 2. TYPICAL PARAMETERS FOR GLIDE SLOPE SITE

Equip. Site	Signal Type	Parameters			
GLIDE SLOPE	ANALOG	1. CLR RF 1	17. CSE(C+SB)P_o	33. CLR Tx 1 DBLR I	49.
		2. CLR SDM 1	18. CSE(SBO)P_o	34. CLR Tripler I	50.
		3. CLR DDM 1	19. CLR(C+SB)P_o	35. CLR 1st PA I	51.
		4. CLR RF 2	20. Upper Ant P_o	36. CLR 2nd PA I	52.
		5. CLR SDM 2	21. Mid Ant P_o	37. 10 Watt Amp I	53.
		6. CLR DDM 2	22. Lwr Ant P_o	38. +18V	54.
		7. Sens DDM 1	23. Batt chg volts	39. Var. volts	55.
		8. Sens DDM 2	24. Batt Chg Amps	40. Det RF	56.
		9. CSE RF 1	25. CSE Tx 1 DBLR I	41. CSE Tx 2 DBLR 2	57. PS Voltage +5
		10. CSE SDM 1	26. CSE Tripler I	42.	58. PS Voltage +5
		11. CSE DDM 1	27. CSE 1st PA I	43.	59. PS Voltage -18
		12. CSE RF 2	28. CSE 2nd PA I	44. Repeat 25 through	60. PS Voltage -18
		13. CSE SDM 2	29. 10 Watt Amp I	45. 40 for Tx 2	61. PS Voltage -50
		14. CSE DDM 2	30. +18V	46.	62. PS Voltage -50
		15. NF DDM 1	31. Var. Volts	47.	63.
		16. NF DDM 2	32. Det RF	48.	64.
	DISCRETE	1. Main On	4. Abn. Monitor	7. Cycle (From Tower)	10.
		2. Stdby On	5. Local Control	8. Interlock Control (From Tower)	11.
		3. Transmitter Off	6. Monitor Locally Bypassed	9.	12

TABLE 3. TYPICAL PARAMETERS FOR MARKER BEACON SITE

Equip. Site	Signal Type	Parameters
MARKER BEACON	ANALOG	1. DC Volts
		2. DC Amps
		3. Driv. Ic
		4. PA Ic
		5. P Fwd.
		6. P Refl.
		7. Audio Bias
		8. Percent Mod
	DISCRETE	1. Main On
		2. Main Off
		3. Abnormal
		4. Local Control
		5. Monitor Bypassed
		6. Cycle (From Tower)
		7.
		8.

TABLE 4. TYPICAL PARAMETERS FOR VOR FACILITY

Equip. Site	Signal Type	Parameters			
		1. Carrier P.O.	17. Line freq.	33. Tx IPA screen-1	49.
		2. S.B. 1 P.O.	18. Temp. room	34. Tx IPA grid-1	50.
	A	3. S.B. 2 P.O.	19. Temp outside	35. Tx PA grid-1	51.
	N	4. Field Int. Mon. 1	20. Temp cone	36. Tx PA screen-1	52.
	A	5. Phase Mon. 1	21. Freq. Dev.	37. Tx PA plate-1	53.
V	L	6. 30 Hz R Mon 1	22. Loss of SB	38. TX OSC cathode-1	54.
O	O	7. 30 Hz V Mon. 1	23. VSWR	39. Tx 1st amp grid-1	55.
R	G	8. 1020 Hz level Mon 1	24. PS Hi Volt 1	40. Tx 1st amp cath-1	56.
		9. 1020 Hz freq. Mon 1	25. PS B + 1	41. Tx 2nd amp grid-1	57.
		10. Field Int Mon 2	26. PS L.V. 1	42. Tx 2nd amp cath-1	58.
		11. Phase Mon 2	27. PS bias supply 1	43.	59.
		12. 30 Hz R Mon 2	28. PS 48V	44.	60.
		13. 30 Hz V Mon 2	29. PS HV2	45. Repeat 43 - 53	61.
		14. 1020 Hz level Mon 2	30. PS B + 2	46. for Tx-2	62.
		15. 1020 Hz freq. Mon 2	31. PS 1V 2	47.	63.
		16. Line volts	32. PS bias supply 2	48.	64.
		1. Ident Mon 1	9. Fil 1 On/Off	17.	
	D	2. Ref Bearing Mon 1	10. Fil 2 On/Off	18.	
	I	3. Ident Mon 2	11. Plate V1 On/Off	19.	
	S	4. Ref Bearing Mon 2	12. Plate V2 On/Off	20.	
	C	5. Intrusion alarm	13. Power Hi/Lo 1	21.	
	R	6. Smoke alarm	14. Power Hi/Lo 2	22.	
	E	7. Tx 1 On/Off	15. Obstruct. light		
	T		On/Off		
	E	8. Tx 2 On/Off	16.	24.	

TABLE 5. TYPICAL PARAMETERS FOR TACAN FACILITY

Equip. Site	Signal Type	Parameters		
	A	1. Avg pwr 1	17. PS 48 V 1	33.
T	N	2. Avg pwr 2	18. PS 500 V 2	34.
A	A	3. Squitter 1	19. PS 250 V 2	35.
C	L	4. 15 Hz Az 1	20. PS + 150 V2	36.
A	O	5. 135 Hz Az 1	21. PS - 150 V 2	37.
N	G	6. Squitter 2	22. PS 48 V 2	38.
		7. 15 Hz Az 2	23.	39.
		8. 135 Hz Az 2	24.	40.
		9. Ant speed (meter)	25.	41.
		10. Temp (duct)	26.	42.
		11. Temp (spin motor)	27.	43.
		12. VSWR	28.	44.
		13. PS 500 V 1	29.	45.
		14. PS 250 V 1	30.	46.
		15. PS + 150 V 1	31.	47.
		16. PS - 150 V 1	32.	48.
	D	1. Rec Sens 1	9. Tx pulse sp 2	17. Mon 1 On/Off
	I	2. Reply delay 1	10. Squitter rate 2	18. Mon 2 On/Off
	S	3. Tx pulse width 1	11. Spectrum	19. Fil 1
	C	4. Tx pulse sp 1	12. Overload 1	20. Fil 2
	R	5. Squitter rate 1	13. Overload 2	21. HV 1
	E	6. Rec Sens 2	14. Ant switch	22. HV 2
	T	7. Reply delay 2	15. Tx 1 On/Off	23.
	E	8. Tx pulse width 2	16. Tx 2 On/Off	24.

Table 6. Parameters Requiring Complex Instrumentation*

Eqpt Site	Parameters	
TACAN	1. Peak power 1	26. Ckt chk mon. reply delay alarm min, 1
	2. Peak power 2	27. Ckt chk mon. reply delay alarm min, 2
	3. North burst duration 1	28. Ckt chk mon. reply delay alarm max 1
	4. North burst duration 2	29. Ckt chk mon. reply delay alarm max 2
	5. Aux burst duration 1	30. Beacon pulse spacing 1
	6. Aux burst duration 2	31. Beacon pulse spacing 2
	7. Ident tone	32. Ckt chk mon pulse spacing alarm min 1
	8. Beacon receiver sensitivity 1	33. Ckt chk mon pulse spacing alarm min 2
	9. Beacon receiver sensitivity 2	34. Ckt chk mon pulse spacing alarm max 1
	10. Sensitivity at +160kHz 1	35. Ckt chk mon pulse spacing alarm max 2
	11. Sensitivity at +160kHz 2	36. Beacon pulse width 1
	12. Sensitivity at -160kHz 1	37. Beacon pulse width 2
	13. Sensitivity at -160kHz 2	38. Ckt chk mon pulse width alarm min 1
	14. Pulses per sec. @ +900kHz 1	39. Ckt chk mon pulse width alarm min 2
	15. Pulses per sec. @ +900kHz 2	40. Ckt check mon pulse width alarm max 1
	16. Pulses per sec. @ -900kHz 1	41. Ckt check mon pulse width alarm max 2
	17. Pulses per sec. @ -900kHz 2	42. Beacon spectrum upper side 1
	18. Beacon RCVR decode tolerance (min) 1	43. Beacon spectrum upper side 2
	19. Beacon RCVR decode tolerance (min) 2	44. Beacon spectrum lower side 1
	20. Beacon RCVR decode tolerance (max) 1	45. Beacon spectrum lower side 2
	21. Beacon RCVR decode tolerance (max) 2	46. Antenna speed
	22. Ckt chk monitor RCVR sens. alarm 1	47. Ckt chk mon. azimuth error alarm 15Hz 1
	23. Ckt chk monitor RCVR sens. alarm 2	48. Ckt chk mon. azimuth error alarm 15Hz 2
	24. Beacon reply delay 1	49. Ckt chk mon. azimuth error alarm 135 Hz 1
	25. Beacon reply delay 2	50. Ckt chk mon. azimuth error alarm 135 Hz 2

*These signals presently require interactive manual measurement techniques.

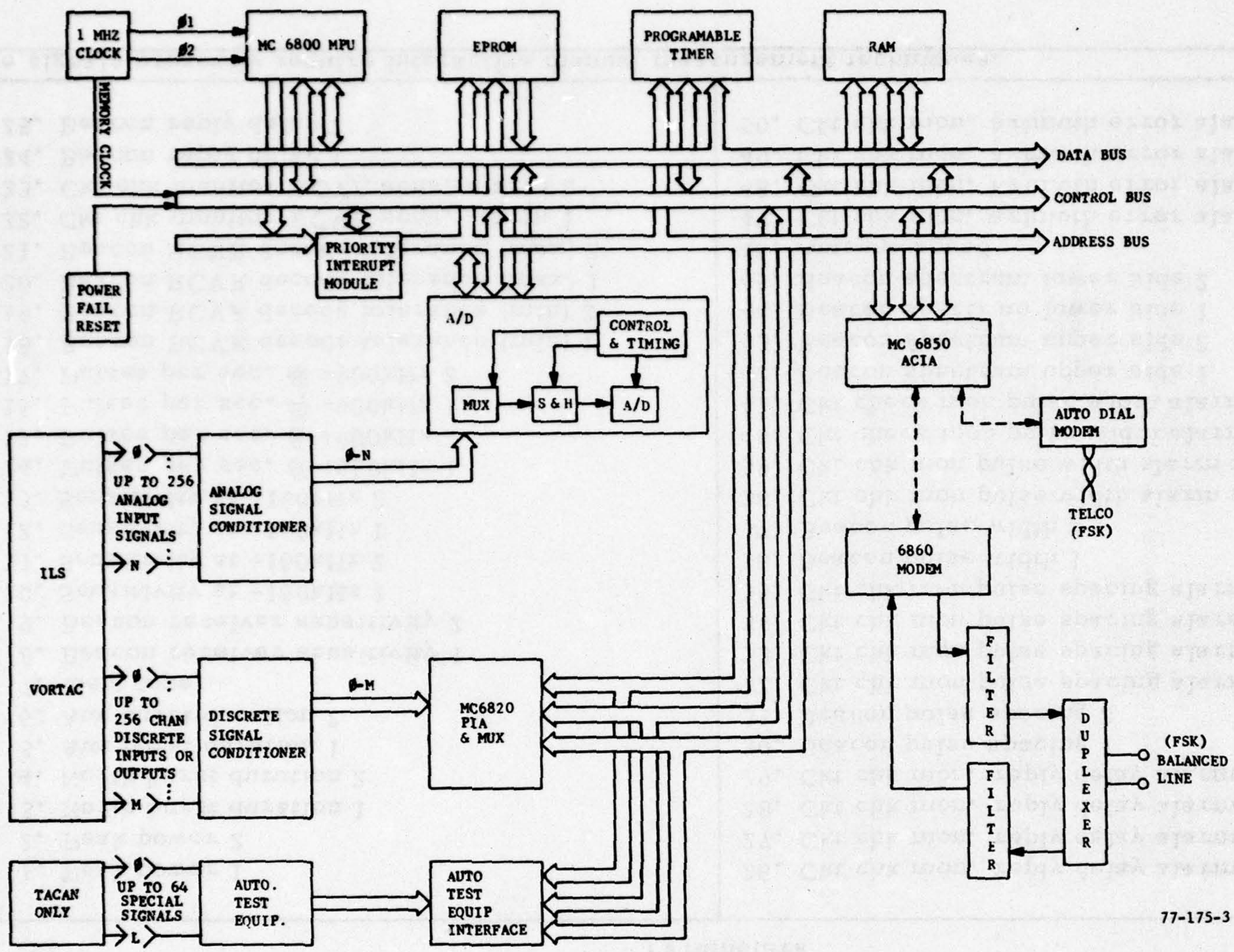

FIGURE 3. FIELD SITE EQUIPMENT CONFIGURATION

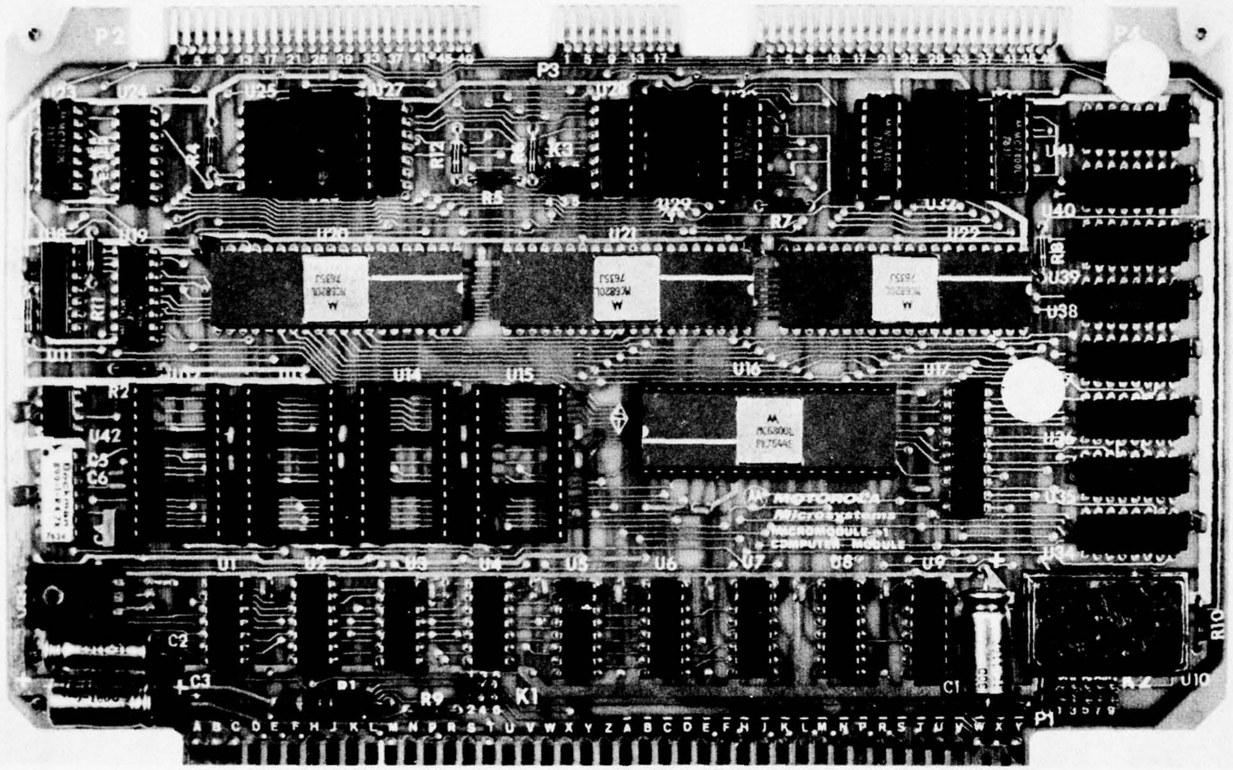

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FIGURE 4. TYPICAL MICROPROCESSOR CARD

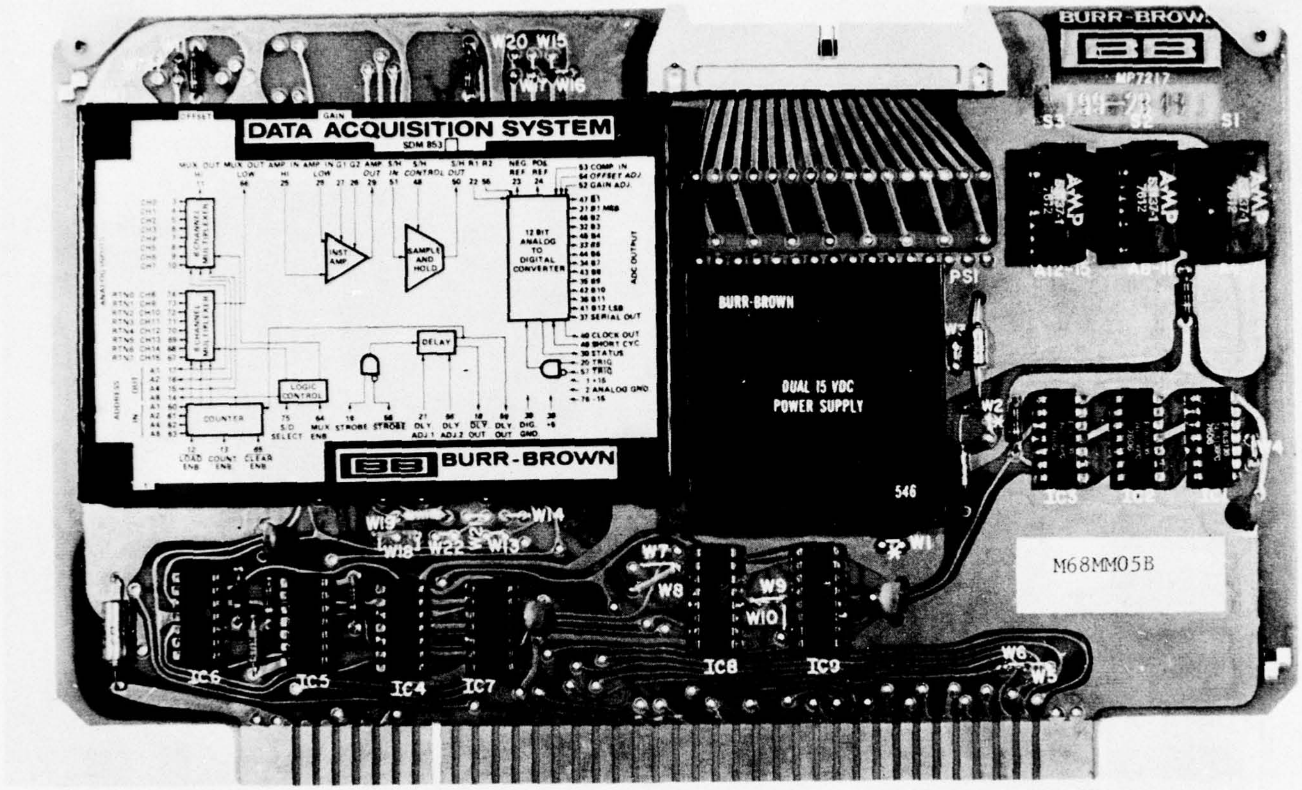

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FIGURE 5. TYPICAL A/D CONVERTER CARD

nonvolatile. Flow charts for a typical RDP program at each field site are illustrated in appendix A (pp. A-1 through A-7).

Discrete signals will also be signal conditioned and entered into the microprocessor. Any change in the logical level of the discrete signal (MAIN ON, STANDBY ON, ABNORMAL, etc.) will generate a priority message. The data sampled at each site will be stored in RAM and updated periodically. Two consecutive data cycles will be stored in RAM, with the third data cycle overwriting the first data cycle. At regular intervals (6 hours or as selected), data will be transmitted on demand from the minicomputer via the MODEMs.

Output from an input to the MODEMs will be frequency shift keyed (FSK) through dedicated and/or dial-up telephone lines. A typical MODEM card, part of a prototype system developed, tested, and evaluated by NAFEC/SRDS/Purdue University is shown in figure 6. These lines will be protected from lightning through the use of transformer isolation, gas discharge tubes, and diodes for surges up to 1000 volts which have been measured on remote communication cables. (Bennison, E., Ghazi, A. J., and Ferland, P., "Lightning Surges in Open Wire, Coaxial and Paired Cables," IEEE Trans. on Comm., Vol. COM-21, Oct. 1973, pp. 1136-1143.)

If desirable, equipment control functions for each site could be incorporated into the system. This would allow the cognizant FAA personnel (i.e., AEA or ATF) to activate control messages to be processed by the microprocessor which in turn will generate a command to activate the appropriate functions.

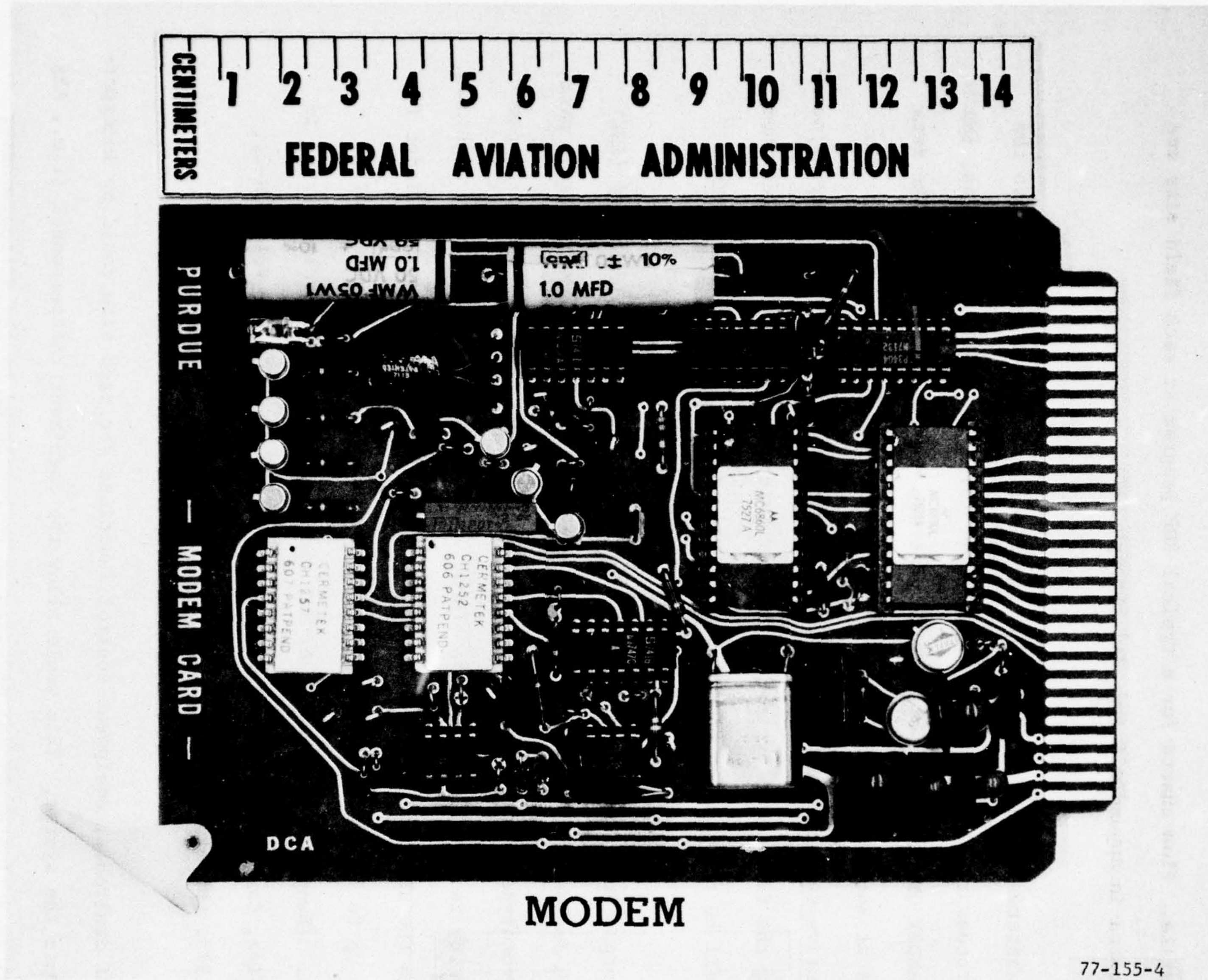


FIGURE 6. TYPICAL MODEM CARD

2.2.3 Message Format.

Each of the signals stored in RAM at each site will be directly addressable through programming. Output through the MODEMs will be a 300-baud in FSK serial binary bit stream. Binary bit stream will be used instead of ASCII for faster data transmissions during routine messages; i.e., 6 seconds vs 18 seconds for a localizer/glide slope site. However, ASCII format will be used between the minicomputer and associated peripherals. Each character will be composed of 11 bits in binary, inclusive of start, stop, and parity bits. Indicated below is the binary format to be used for data transmission from the field sites.

	B O I	NAVAIDS Plus Eqpt. Site	Signal Address	Value Of Parameters	Signal Address	Value of Parameters	E O T
Char.	xx	x	x	x	x	x	xx

2.2.4 Special Features.

2.2.4.1 Self-Checking.

Special hardware/software self-checking features will be incorporated into the RDP system such as parity, checksum, as well as handshake logic with errors logged.

2.2.4.2 Standardization.

All models will be standardized for interchangebility wherever possible, thereby reducing logistics requirements.

2.2.4.3 Flexibility.

Two sets of signal conditioner and associated A/D cards are envisioned for each NAVAID. All will be interchangeable within a given set.

2.3 Central Control and Display Configuration.

2.3.1 General.

Figure 7 represents the equipment configuration of the Central Control and Display site. All data received at the Central Control Display area will be processed through the minicomputer for subsequent display. This data will also be recorded for legal and historical purposes on an industry compatible nine-track tape. Tape playback will be off-line, or, as an option with additional equipment. Additionally, as stated previously, the cognizant FAA personnel (i.e., AEA/ATF) could be capable of controlling the on/off functions of the NAVAID. The status data can be displayed upon request.

2.3.2 CCC System Operation.

A minicomputer such as the PDP-11/40 will be the Central Control Computer (CCC). This minicomputer was chosen because of its expandability (memory expansion) and will have the capacity for future inclusion of other NAVAID monitored parameters. The minicomputer will be programmed to provide the functions illustrated in the CCC flow chart (appendix B, pp. B-1 through B-11). Storage of RDP alarm limits for each monitored parameter as well as executive

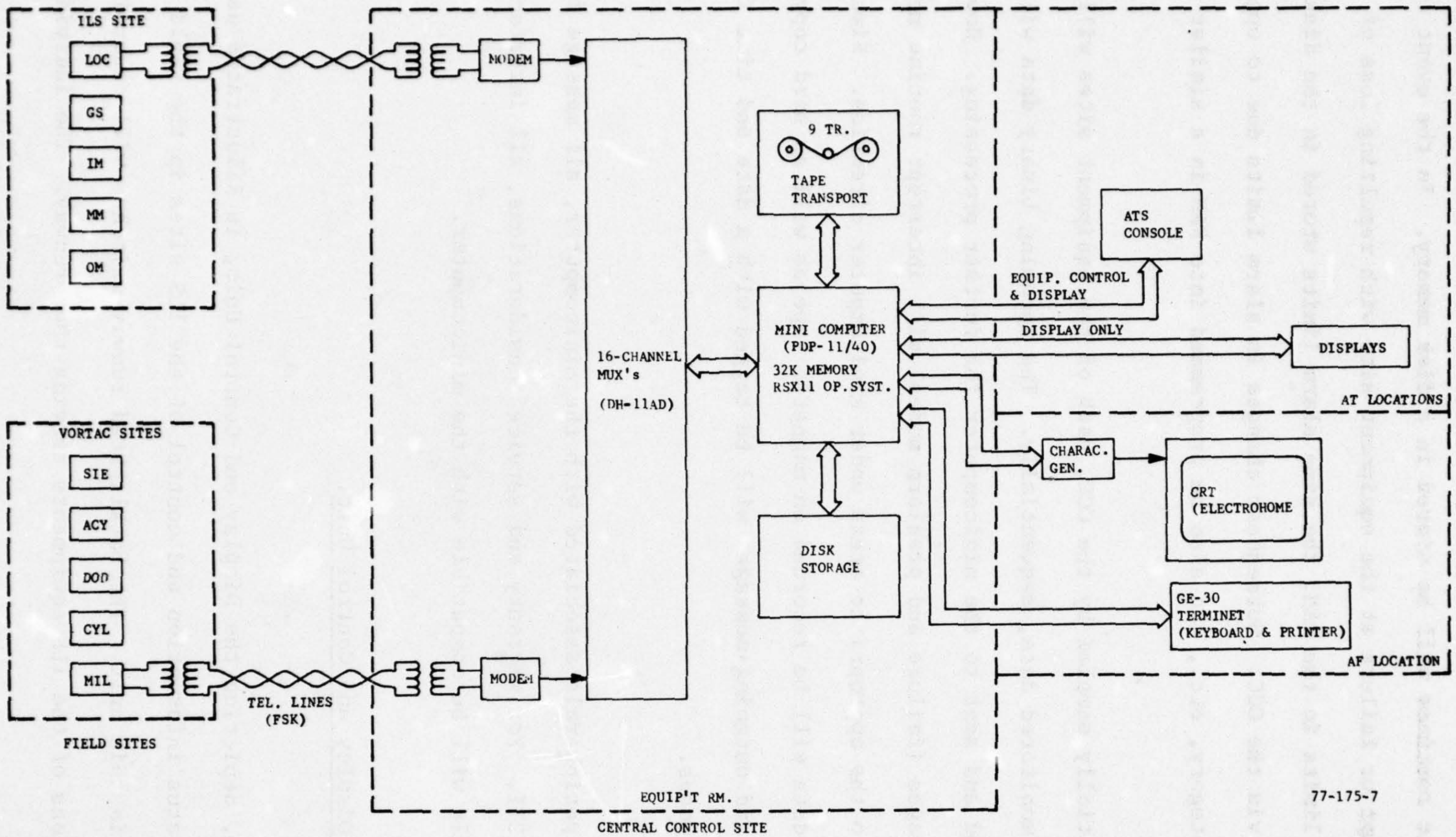


FIGURE 7. CENTRAL CONTROL AND DISPLAY CONFIGURATION

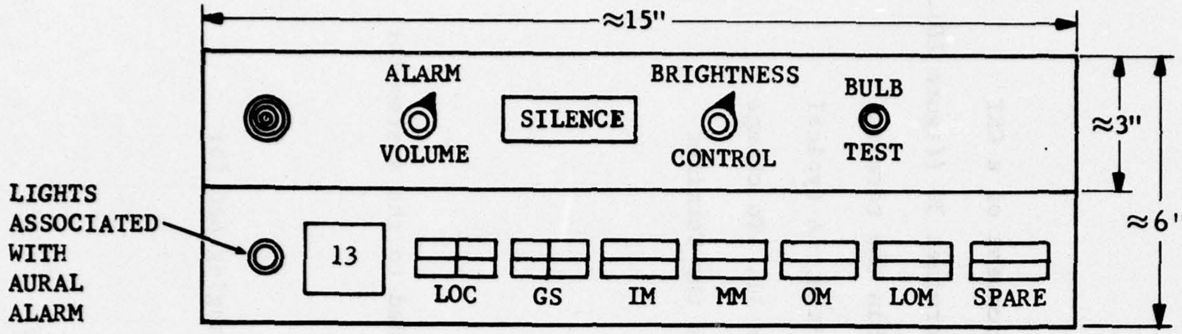
and diagnostic routines will be stored in a disk memory. In the event of a power interrupt or failure at the equipment site with resulting loss of stored alarm limits in the RAM, the same alarm limits stored in the disk will be reentered via the CCC. Subsequent changes in alarm limits due to upgrading of service category, etc., can also be programmed into RAM in a similar manner.

When initially sampled by the CCC, each of the equipment sites will transmit FSK monitored data, sequentially. The incoming binary data will be multiplexed and sent to the minicomputer for further processing. However, priority messages (failure and prealarm modes) will interrupt routine messages and be sent to the appropriate areas under minicomputer direction. Simultaneously, this data will be recorded on magnetic tape as well as hard copy. All incoming and outgoing messages will be tagged with a date and time for recording purposes.

For all peripherals associated with the minicomputer, all message formats will be in ASCII. For warranty and service considerations, all interfaces and peripherals will be compatible with the minicomputer.

2.3.2.1 ILS Display and Control Unit.

A sketch, depicting the Display and Control Unit, is illustrated as figure 8. Status information and control of the ILS sites in the field can be obtained via this unit. The backlighted runway switches will control the ON/OFF functions of the ILS equipments serving that runway. The individual



NOTE: COLOR CODING

A. GREEN - MAIN ON, NO ALARMS
B. AMBER - 1. ONE OR MORE MONITORS ARE IN ALARM
2. STBY ON
3. TEMP, AC, BATTERY CHARGER, FAIL, ETC.

C. AMBER (BLINKING)
1. - IN LOCAL
2. - MONITOR BY-PASSED

D. RED - STATION OFF
E. CYCLE SWITCH - FOR GS & LOC

MAIN	STBY
OFF	ABN.

F. CYCLE SWITCH FOR MARKER

NORMAL
ALARM

77-175-8

FIGURE 8. ILS DISPLAY AND CONTROL UNIT

ILS sites will be controlled by the switches associated with the field site. In the event of a CCC failure, all lights on the console will illuminate.

2.3.2.2 Maintenance Supervisor's Display and Terminal.

The maintenance supervisor's display will primarily consist of a CRT display (figure 9) and a hard copy printer, such as the Terminet 30 (figure 10). Additionally, the supervisor will have the capability within the terminal keyboard to request specific data from any of the field sites. A typical display showing field status on the CRT is shown as figure 11. To change a monitor alarm limit, the maintenance supervisor will use the Terminet keyboard to enter the new values.

3.0 OPTIONAL/FUTURE CONSIDERATIONS

The following optional items and equipment can be added to the system for increasing flexibility and redundancy:

a. Additional Tape Transport - For ease of tape changing and for dumping tape data on-line without loss of incoming data.

b. Additional Minicomputer - For on-line redundancy.

c. Additional Display - FSS VORTAC display can be added, if desired. Present test model does not include display for ATS.

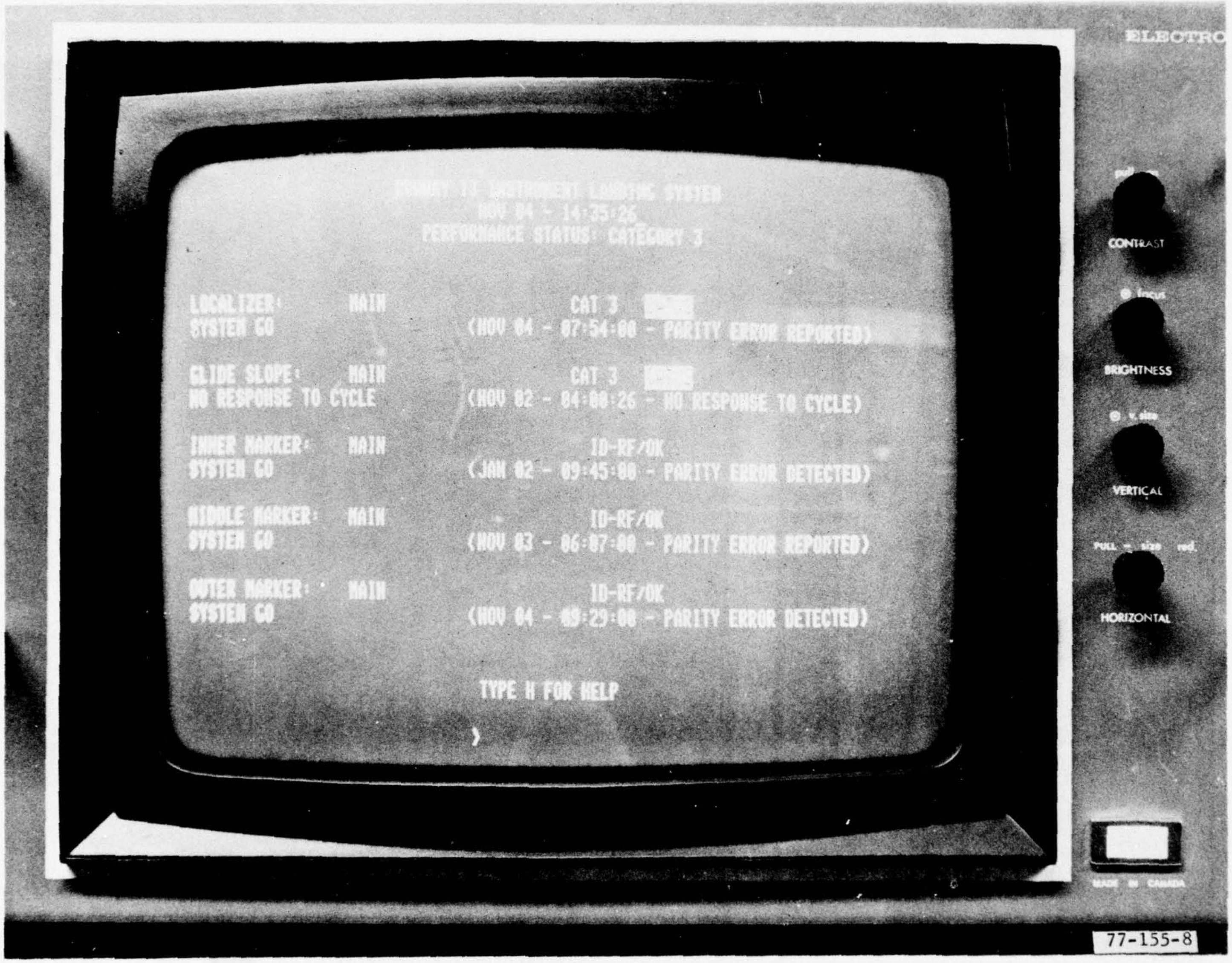


FIGURE 9. MAINTENANCE SUPERVISOR DISPLAY (CRT - ILLUSTRATING ILS MENU)

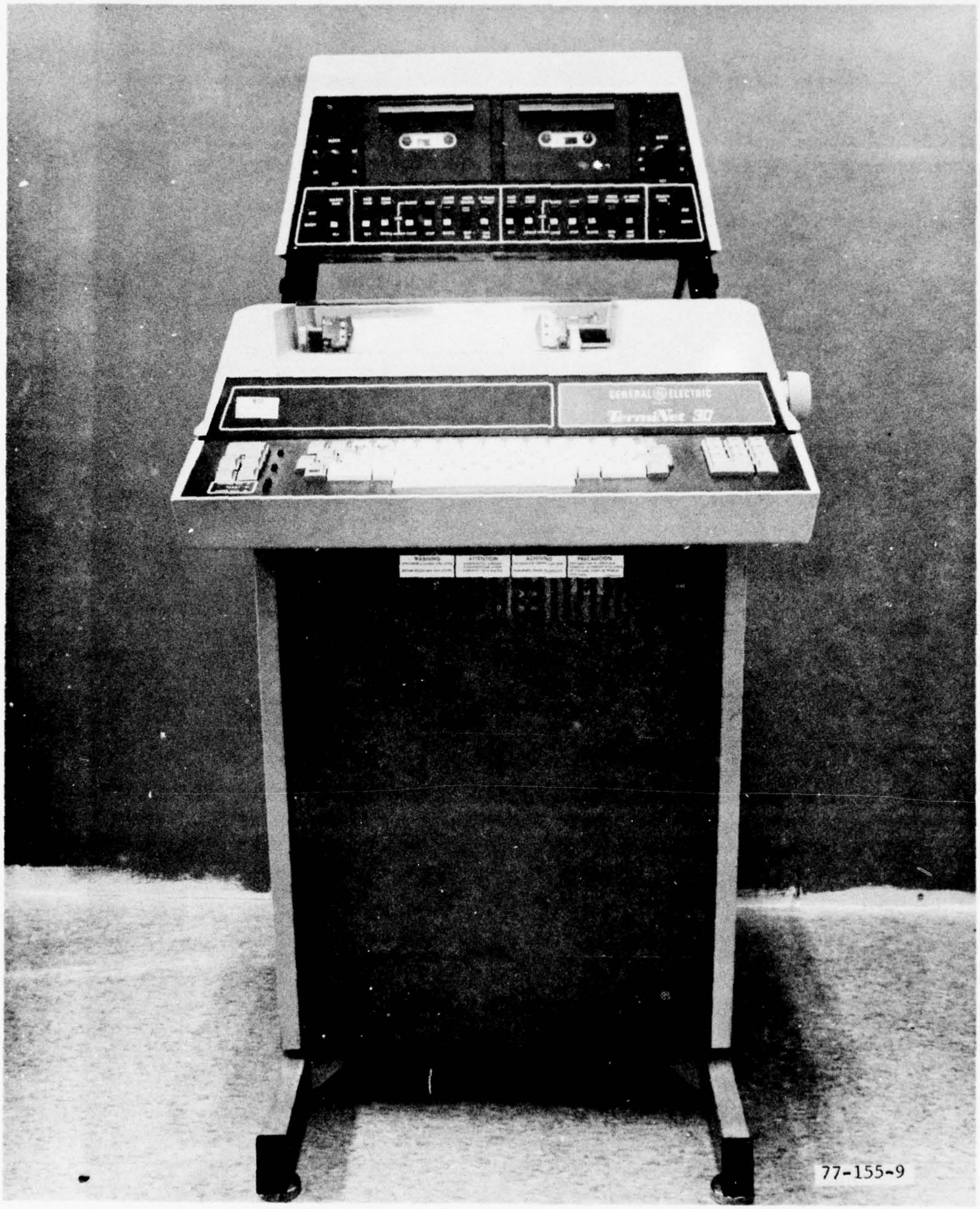


FIGURE 10. MAINTENANCE SUPERVISOR TERMINAL (TERMINET 30)

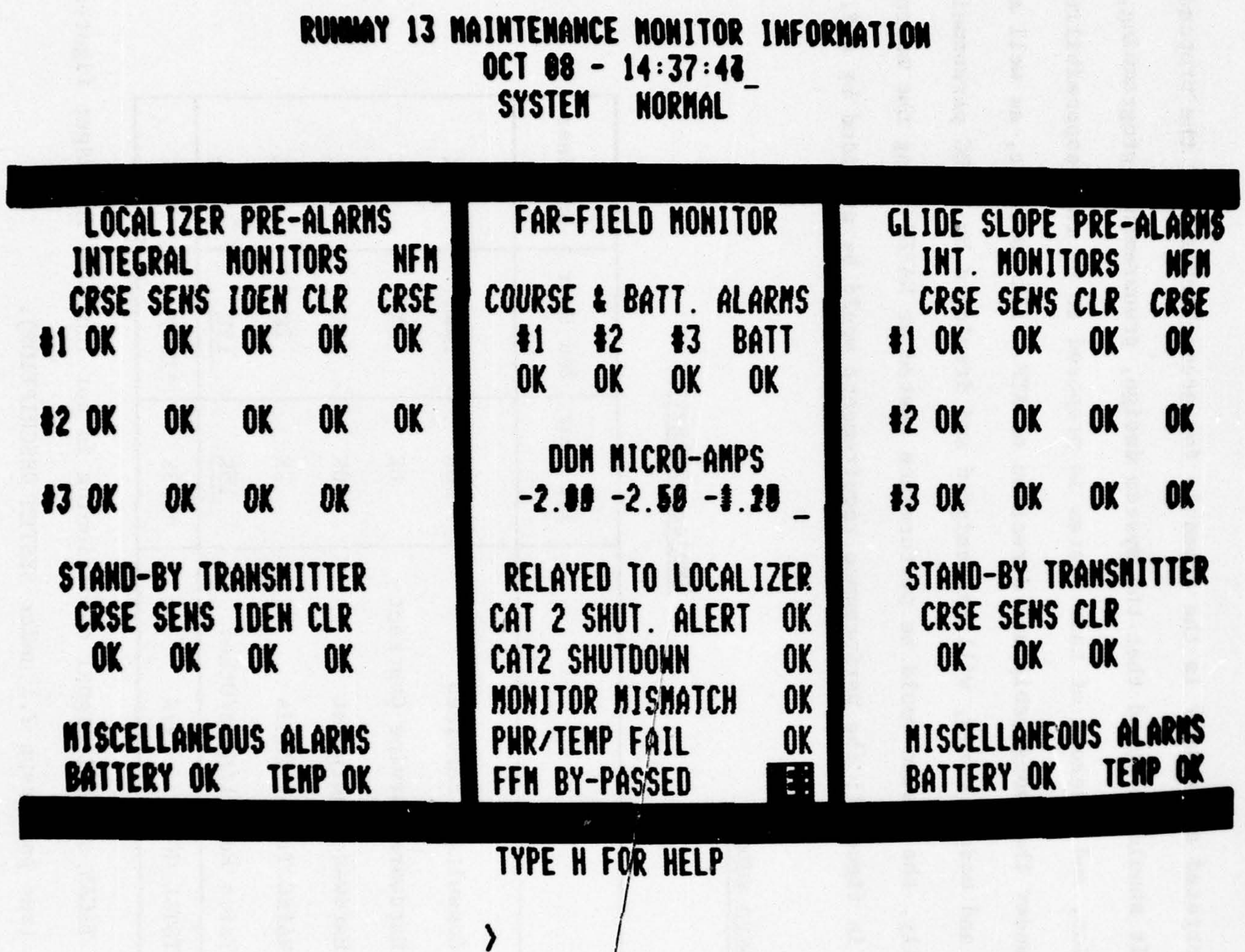


FIGURE 11. MAINTENANCE SUPERVISOR DISPLAY (TYPICAL ILS READOUT)

4.0 SCHEDULE FOR ACCOMPLISHMENT

Illustrated as table 7 is the schedule for accomplishment of the proposed system. It should be noted that the system design, procurement, programming, installation, and checkout of this system is proposed to be the responsibility of NAFEC under the sponsorship and direction of ATF. All software, as well as interface and module cards, will be designed and developed by NAFEC personnel. Additionally, the system would be performance tested at NAFEC using the sector indicated in figure 1; the performance requirements would be provided by ATF.

5.0 PROPOSED BUDGET

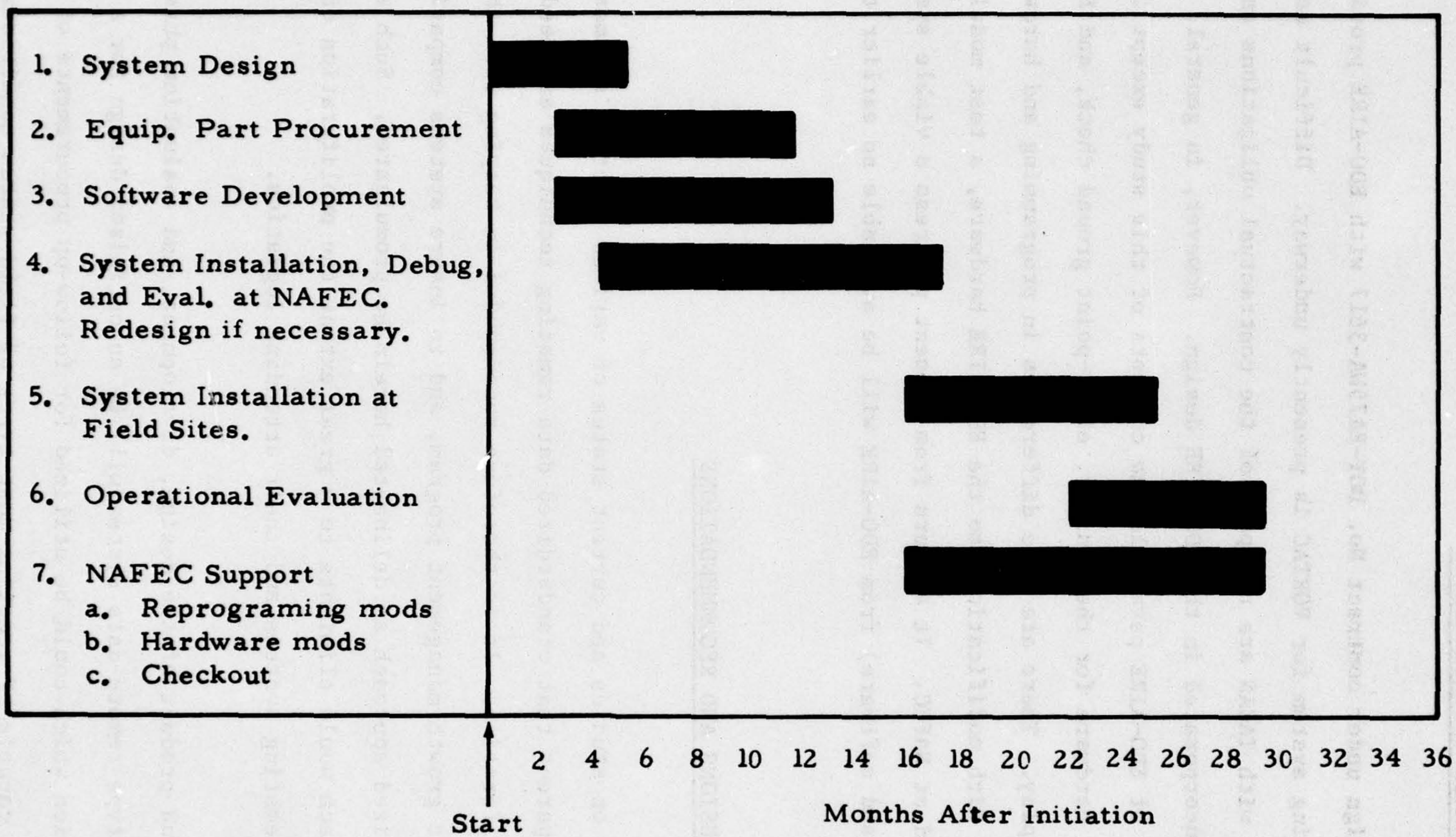
Project Budget

	1st Year	2nd Year	3rd Year
Consultant Services	10K	10K	10K
Hardware Service Contract	6K	6K	6K
Hardware/Equipment	100K	75K	25K
NAFEC Travel Funds	2K	2K	2K
Telco Rental/Misc/Other	15K	15K	15K
TOTAL COST 299K	*133K	*108K	*58K

NOTES: 1. TACAN special signal conditioning is not included in budget figures (see paragraph 2.1 under SYSTEM DESCRIPTION).

2. (*) Budget figures do not include NAFEC manpower costs (10 manyears).

TABLE 7. SCHEDULE FOR ACCOMPLISHMENT



6.0 ALTERNATE CONSIDERATIONS

A design under contract No. DOT-FA75WA-3617 with EDO-AIRE providing for data remoting system for VORTAC is presently underway. Difficult measurements associated with TACAN are not part of the contractual obligations and are therefore not incorporated in the EDO-AIRE design. However, in general, the basic philosophy of EDO-AIRE parallels the concepts of this study except for their additional hardware for the monitor, eight-point ground check, and FSS ATC remote display. There are some differences in programming and hardware concepts, but with modifications to the EDO-AIRE hardware, a test model can be established at NAFEC. It appears from present progress a viable system (hardware and software) from EDO-AIRE will be available no earlier than July 1977.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on studies and current status of various remoting schemes, it becomes apparent that standardized data remoting techniques are needed to avoid proliferation. It is therefore recommended in keeping with the FAA's maintenance growth management program, and to insure systems compatibility, a standardized approach as delineated herein be promulgated. Such a standardized approach would eliminate to a great extent the proliferation of the many types of remoting systems and their attendant logistics.

The end product of the design, development, and evaluation phases of this prototype remote data system will be an optimized design for a production specification which could be utilized for follow-up procurements of an overall system capable of remoting most types of field status conditions.

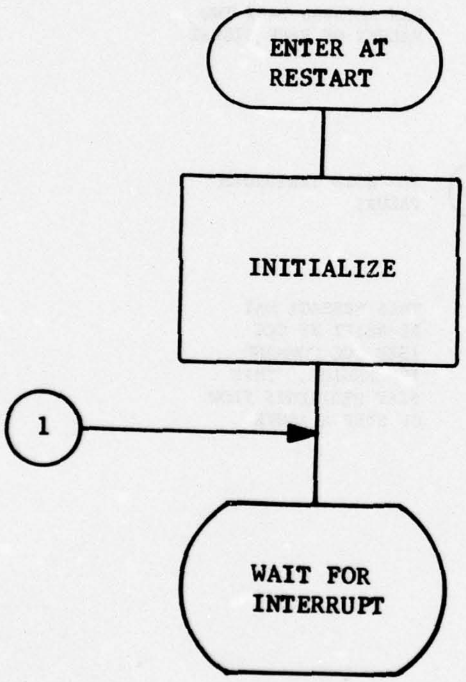
GLOSSARY

A	Availability
ACIA	Asynchronous Communications Interface Adapter
A/D	Analog-to-Digital Converter (associated with digitizing of analog data).
AEA	Eastern Region
AFS	Airway Facilities Service
ATS	Air Traffic Service
BOI	Beginning of Information
CCC	Central Control Computer (located at the tower, accepts data from all RDP sites and distributes information and commands to various peripherals).
CRT	Cathode Ray Tube (used for display of digitized information on a video presentation).
EOT	End of Transmission
EPROM	Erasable, Programmable Read Only Memory.
FSK	Frequency Shift Keying (transmission of Logical 1's and Ø's via two tones).
LED	Light Emitting Diode.
MODEM	Modulator/Demodulator (converts digital data to FSK and vice versa).
MPU	Microprocessor Unit.
MTBF	Mean Time Between Failures
MTTR	Mean Time to Restore
PIA	Peripheral Interface Adapter
RAM	Random Access Memory
RDP	Remote Data Processor
TACAN	Tactical Air Navigation
VOR	VHF Omnidirectional Range

APPENDIX A

TYPICAL FLOW CHARTS FOR REMOTE DATA PROCESSOR (RDP)

RDP SOFTWARE FLOWCHART



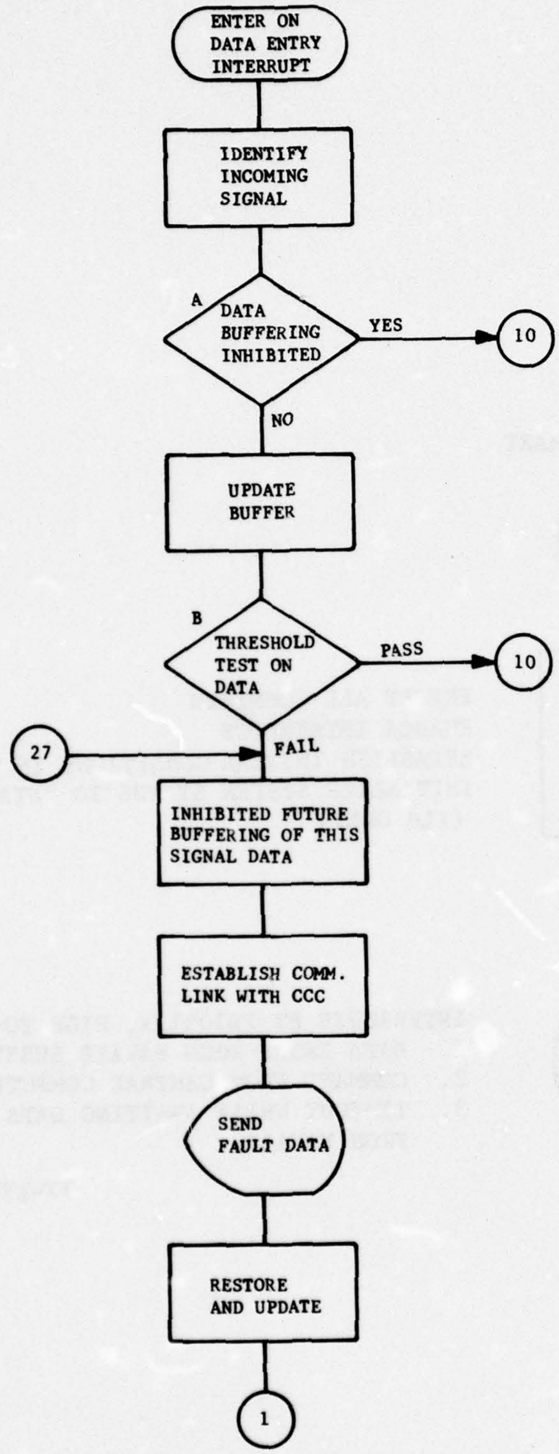
PRESET ALL COUNTERS
ENABLE INTERRUPTS
ESTABLISH INITIAL CONDITIONS IN RAM
INITIALIZE SYSTEM STATUS TO "STANDBY" (ILS ONLY)

INTERRUPTS BY PRIORITY, HIGH TO LOW

1. DATA ENTRY FROM NAVAID SUBSYSTEM
2. COMMAND FROM CENTRAL COMPUTER
3. TIMEOUT WHILE AWAITING DATA ENTRY FROM NAVAID.

77-175-A-1

RDP SOFTWARE FLOWCHART



PRIORITY 1 INTERRUPT
RECOVERY

SIGNAL MAY BE ANALOG OR DIGITAL
ACCORDING TO A PREDETERMINED
TIME DIVISION MULTIPLEXING SCHEME

MAY BE INHIBITED BECAUSE
OF SUBSYSTEM SHUTDOWN BY
CCC OR PREVIOUS FAILURE
(ASSUME INTERRUPTS CONTINUE)

RAM RETAINS LAST TWO
VALUES OF EACH SIGNAL

RAM HOLD THRESHOLD
VALUES

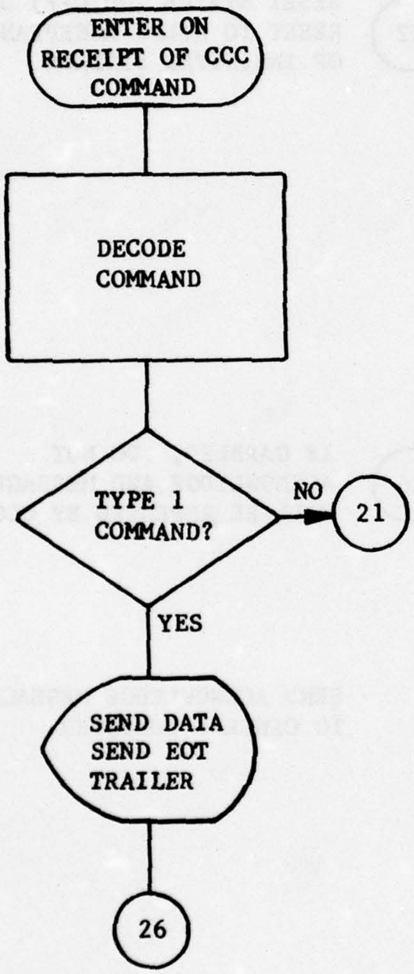
THIS MESSAGE MAY
BE RESET BY CCC
(SEE CCC COMMAND
PROCESSING. THIS
STEP REDIRECTS FLOW
OF STEP A ABOVE.

SYSTEM
MUST
RECEIVE SIGNALS
AT REGULAR
INTERVALS OR
TIMEOUT

REENABLE
INTERRUPT
AND RETURN

77-175-A-2

RDP SOFTWARE FLOWCHART



PRIORITY 2 INTERRUPT
RESPONDS TO ENTRY OF
COMMAND FROM
CENTRAL COMPUTER
POSSIBLE COMMANDS INCLUDE

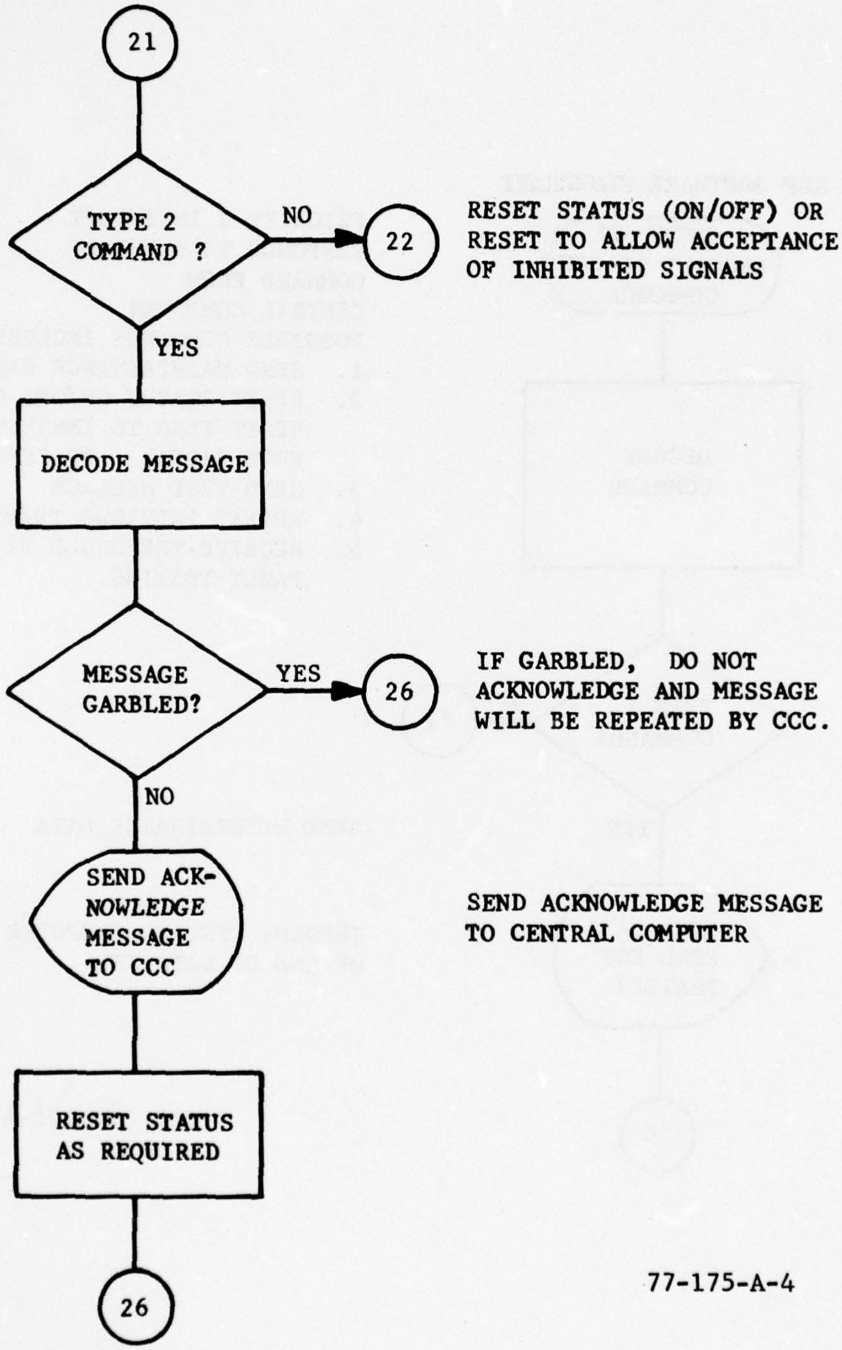
1. SEND MAINTAINANCE DATA
2. RESET STATUS ON/OFF OR RESET FLAG TO INHIBIT DATA FROM SIGNAL (SEE TEST A)
3. SEND TEST MESSAGE
4. REPEAT PREVIOUS TRANSMISSION
5. RECEIVE THRESHOLD VALUES FOR FAULT TESTING

SEND MAINTAINANCE DATA

INFORMS CENTRAL COMPUTER
OF END OF DATA SET

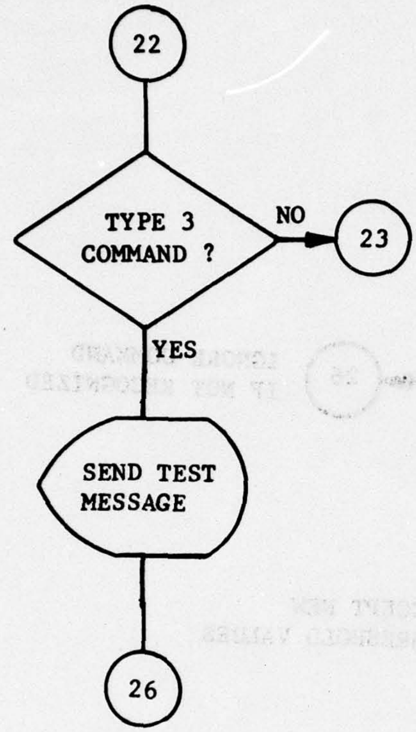
77-175-A-3

RDP SOFTWARE FLOWCHART



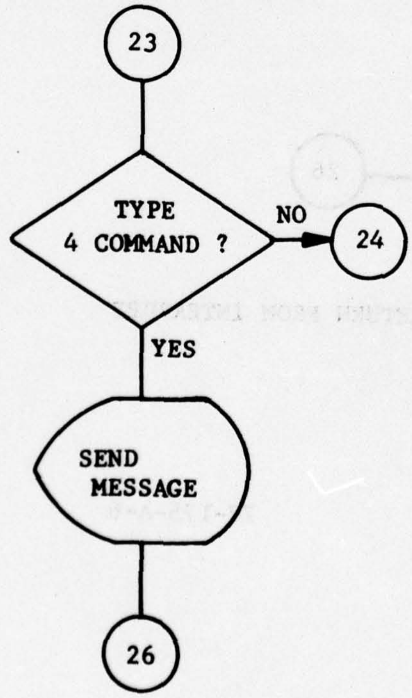
77-175-A-4

RDP SOFTWARE FLOWCHART



SEND TEST MESSAGE

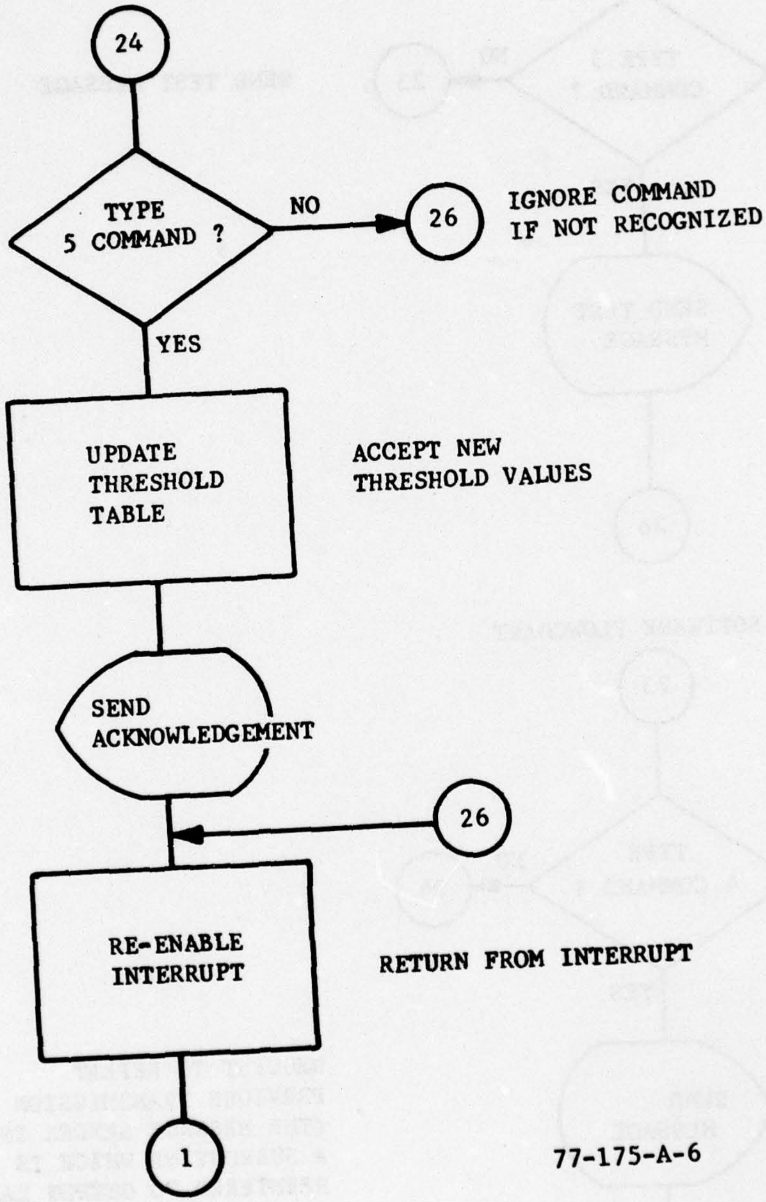
RDP SOFTWARE FLOWCHART



REQUEST TO REPEAT PREVIOUS TRANSMISSION (THE MESSAGE SENDER IS A SUBROUTINE WHICH IS REENTERED TO OUTPUT LAST BUFFER BUILT)

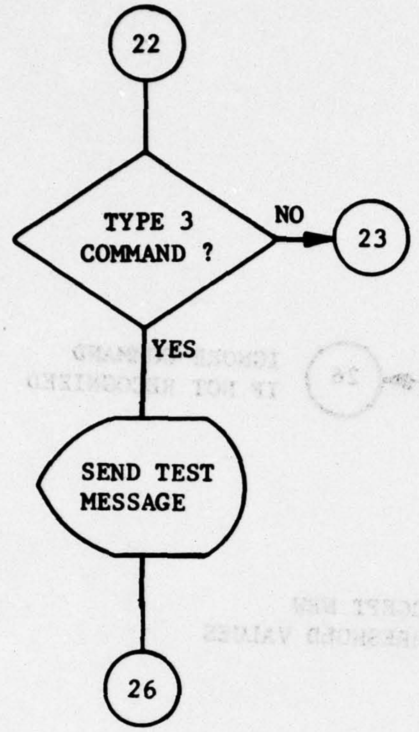
77-175-A-5

RDP SOFTWARE FLOWCHART



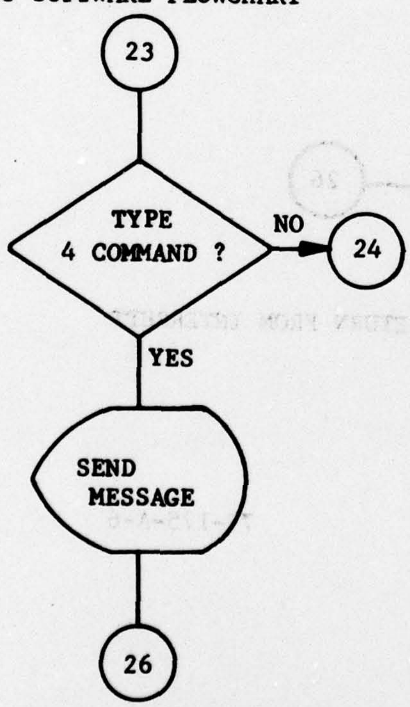
77-175-A-6

RDP SOFTWARE FLOWCHART



SEND TEST MESSAGE

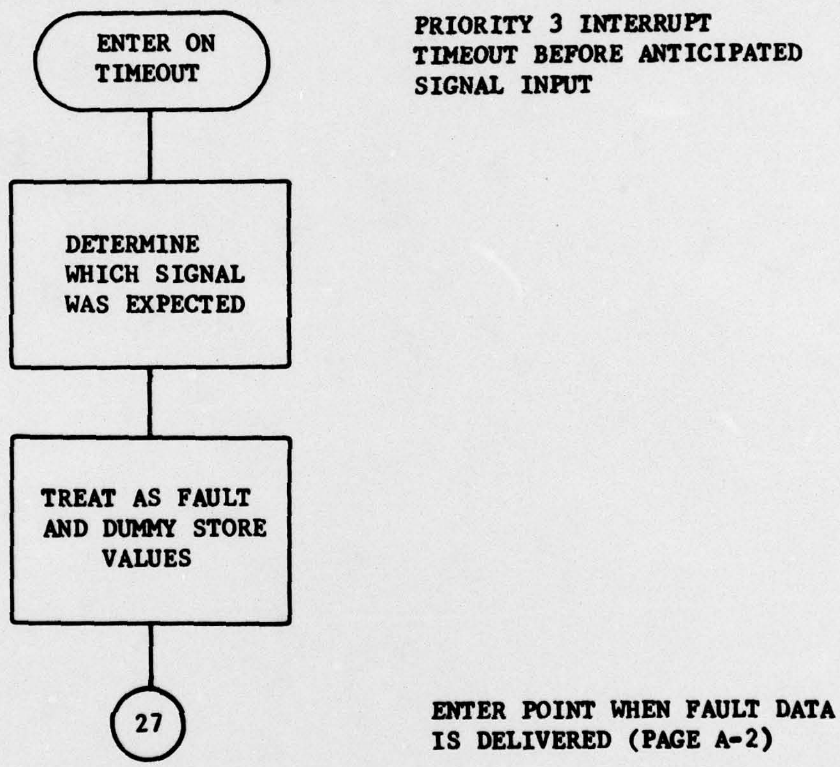
RDP SOFTWARE FLOWCHART



REQUEST TO REPEAT PREVIOUS TRANSMISSION (THE MESSAGE SENDER IS A SUBROUTINE WHICH IS REENTERED TO OUTPUT LAST BUFFER BUILT)

77-175-A-5

RDP SOFTWARE FLOWCHART

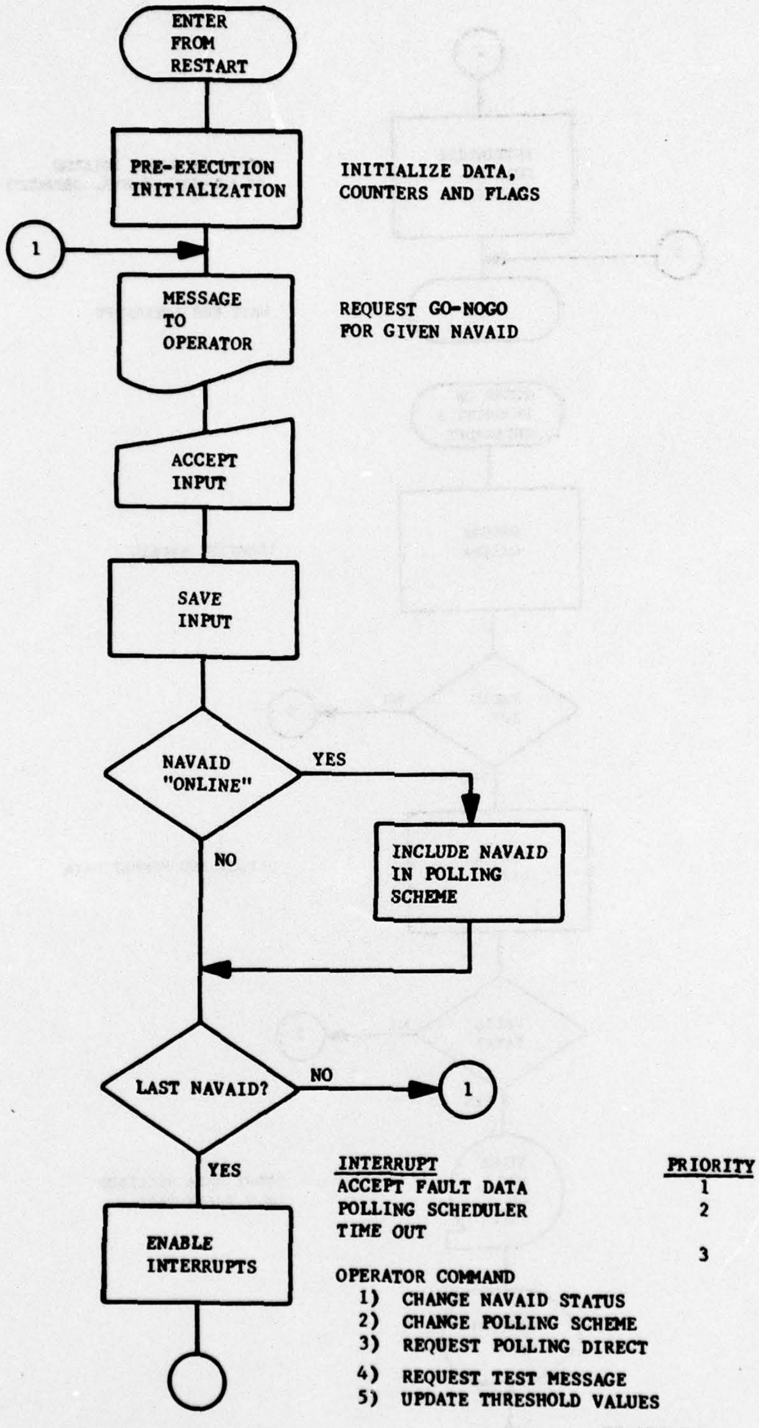


77-175-A-7

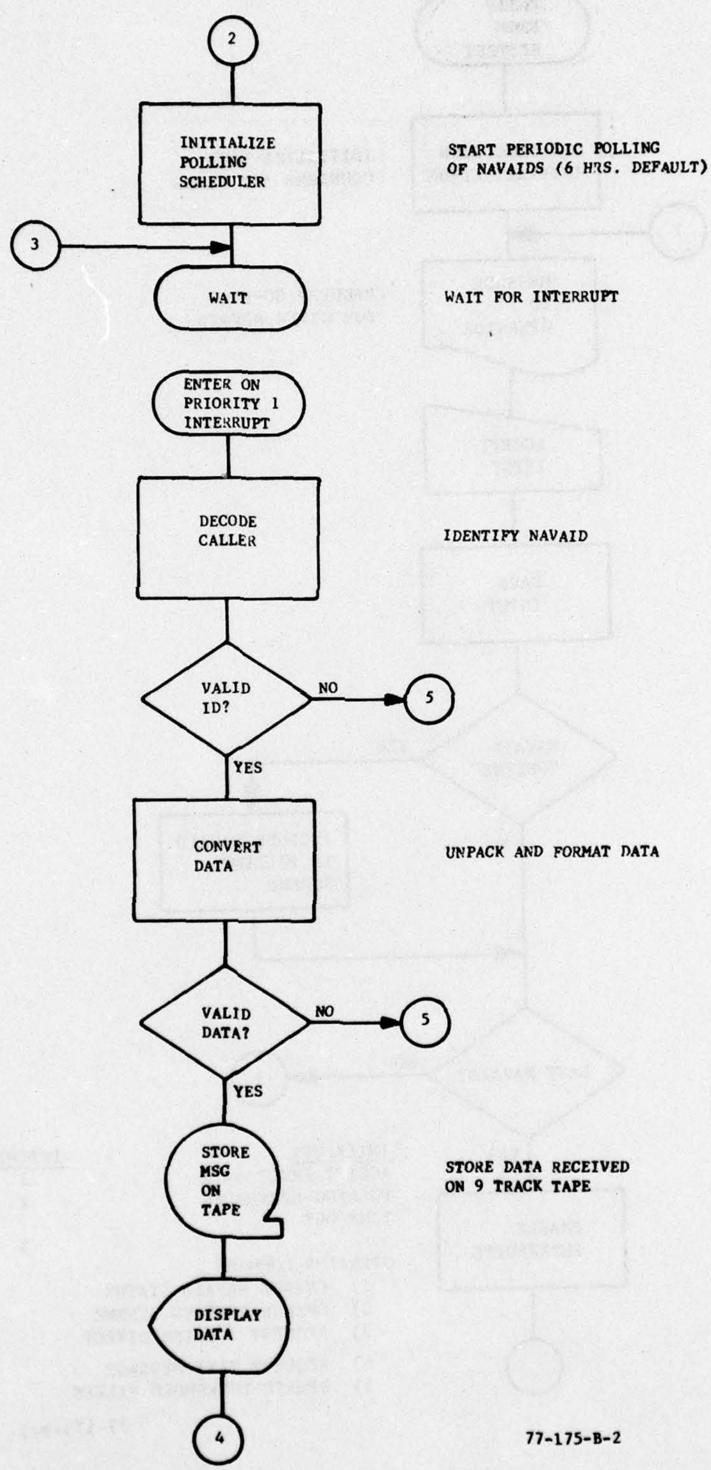
APPENDIX B

TYPICAL FLOW CHARTS FOR CENTRAL CONTROL COMPUTER (CCC)

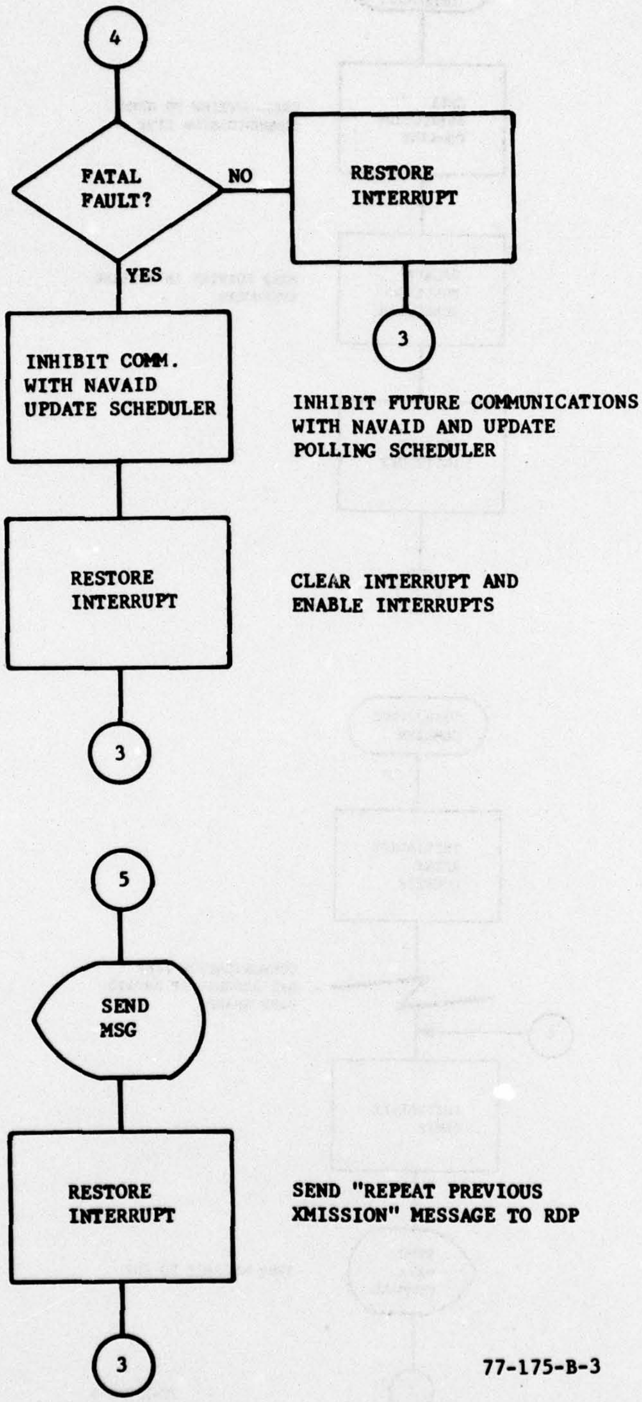
CCC SOFTWARE FLOW CHART



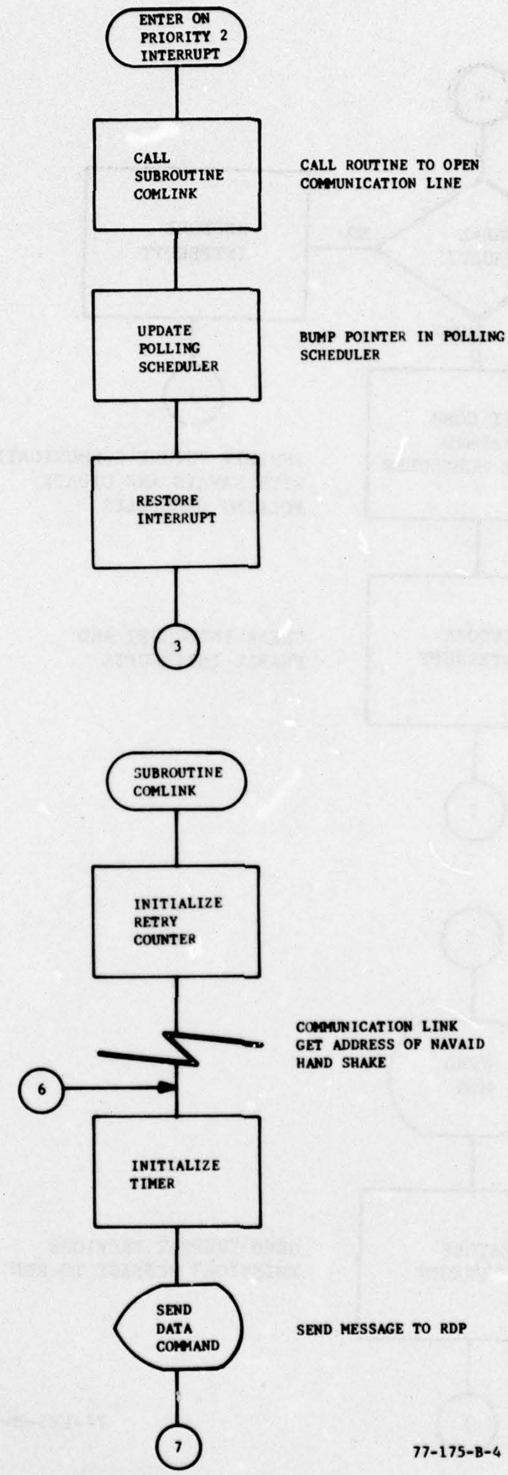
77-175-B-1


2
INITIALIZE POLLING SCHEDULER
START PERIODIC POLLING OF NAVAIDS (6 HRS. DEFAULT)
3
WAIT
WAIT FOR INTERRUPT
ENTER ON PRIORITY 1 INTERRUPT
DECODE CALLER
IDENTIFY NAVAID
VALID ID?
NO
5
YES
CONVERT DATA
UNPACK AND FORMAT DATA
VALID DATA?
NO
5
YES
STORE MSG ON TAPE
STORE DATA RECEIVED ON 9 TRACK TAPE
DISPLAY DATA
4

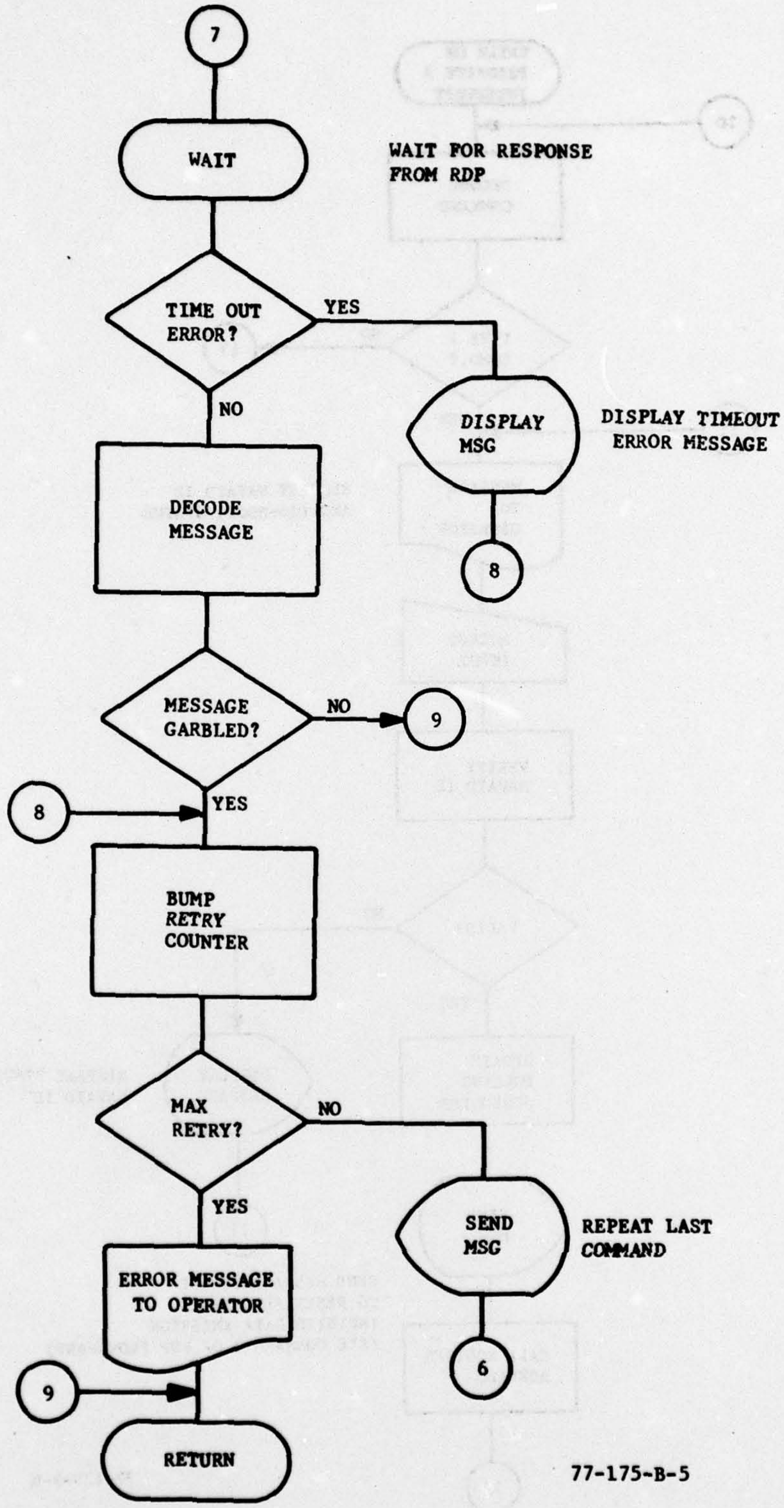
77-175-B-2

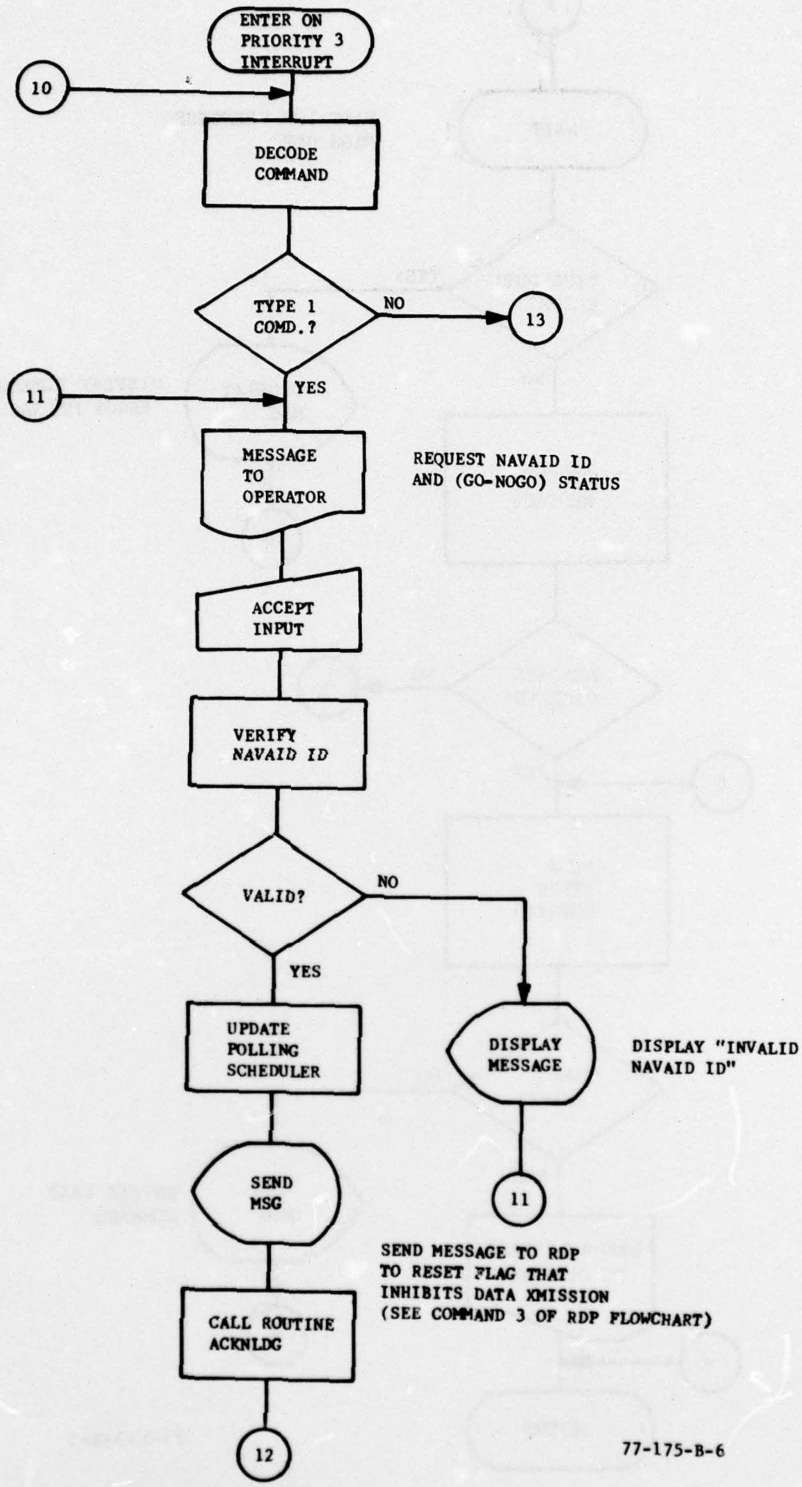

4
FATAL FAULT?
NO
RESTORE INTERRUPT
3
YES
INHIBIT COMM. WITH NAVAID UPDATE SCHEDULER
INHIBIT FUTURE COMMUNICATIONS WITH NAVAID AND UPDATE POLLING SCHEDULER
RESTORE INTERRUPT
CLEAR INTERRUPT AND ENABLE INTERRUPTS
3
5
SEND MSG
RESTORE INTERRUPT
SEND "REPEAT PREVIOUS XMISSION" MESSAGE TO RDP
3

77-175-B-3

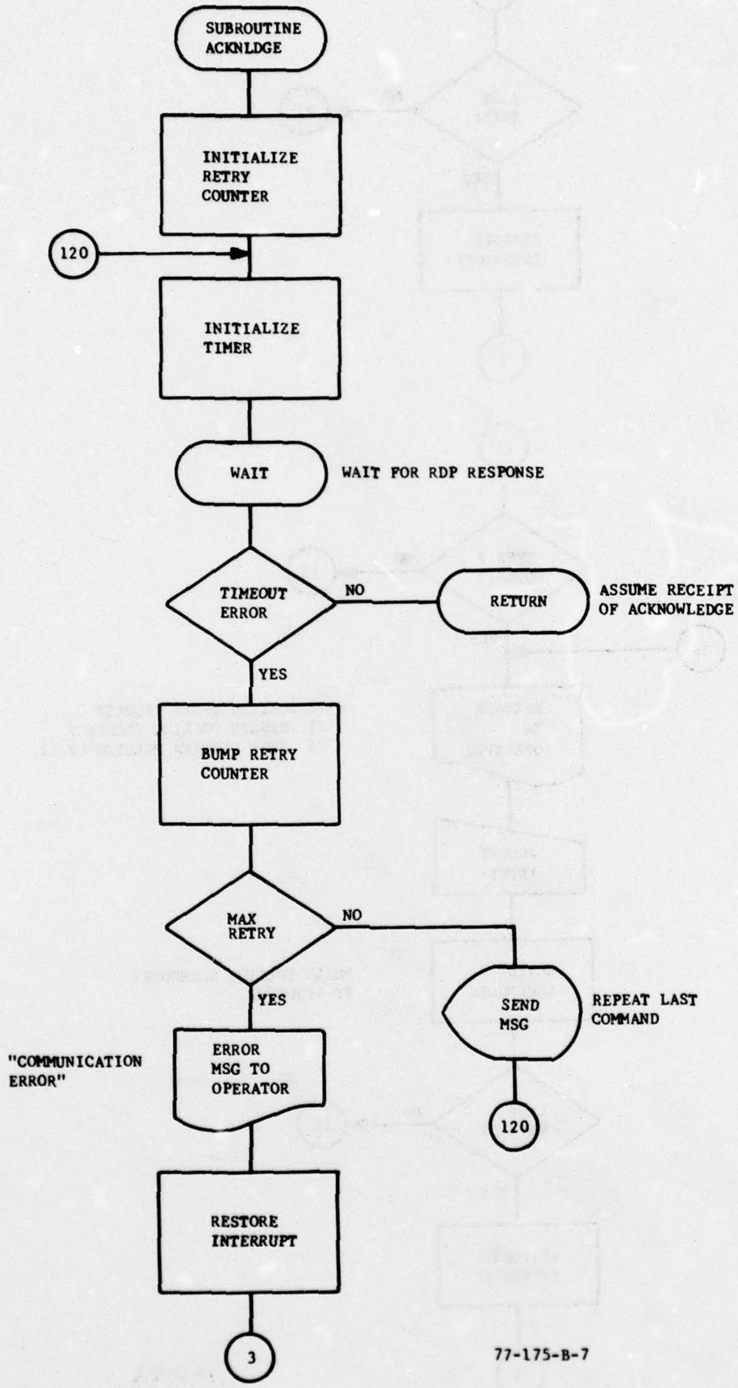

ENTER ON PRIORITY 2 INTERRUPT
CALL SUBROUTINE COMLINK
CALL ROUTINE TO OPEN COMMUNICATION LINE
UPDATE POLLING SCHEDULER
BUMP POINTER IN POLLING SCHEDULER
RESTORE INTERRUPT
3
SUBROUTINE COMLINK
INITIALIZE RETRY COUNTER
COMMUNICATION LINK
GET ADDRESS OF NAVAID
HAND SHAKE
6
INITIALIZE TIMER
SEND DATA COMMAND
SEND MESSAGE TO RDP
7

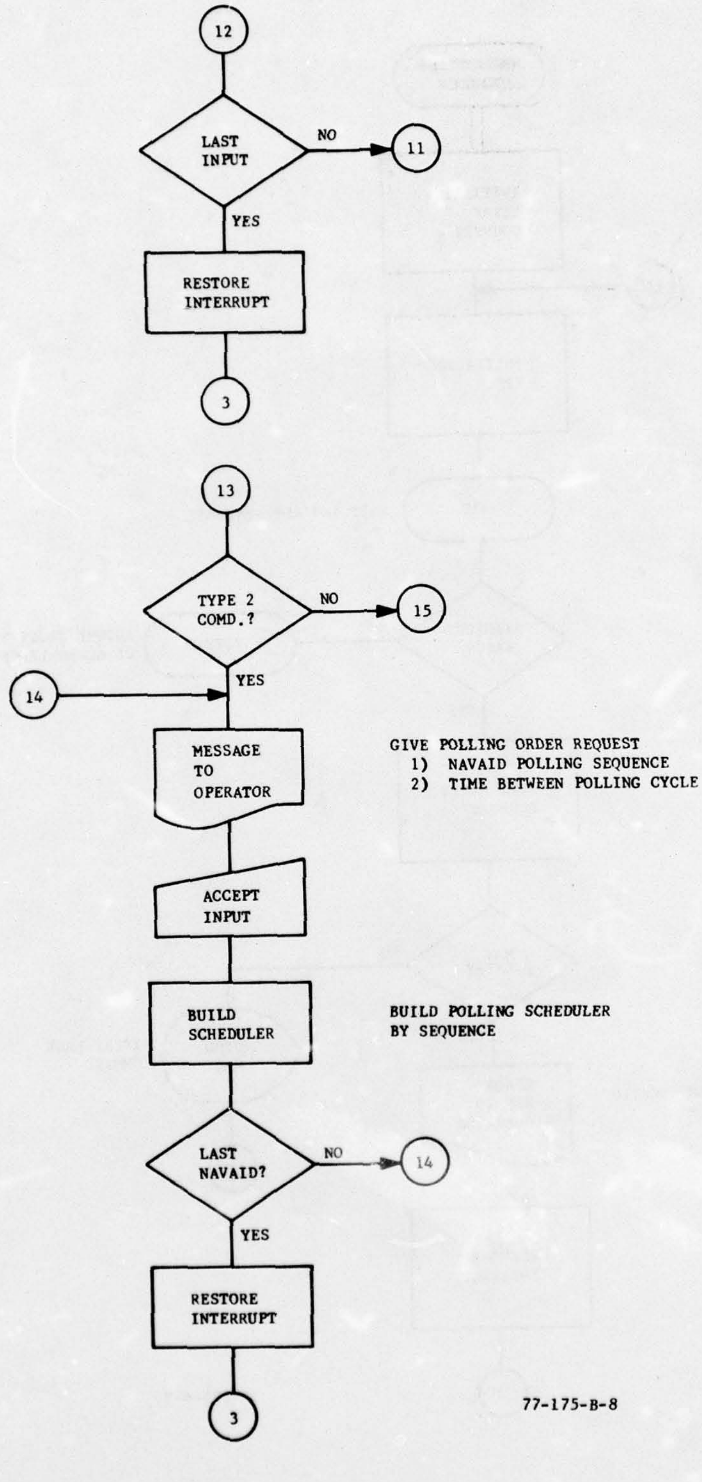
77-175-B-4

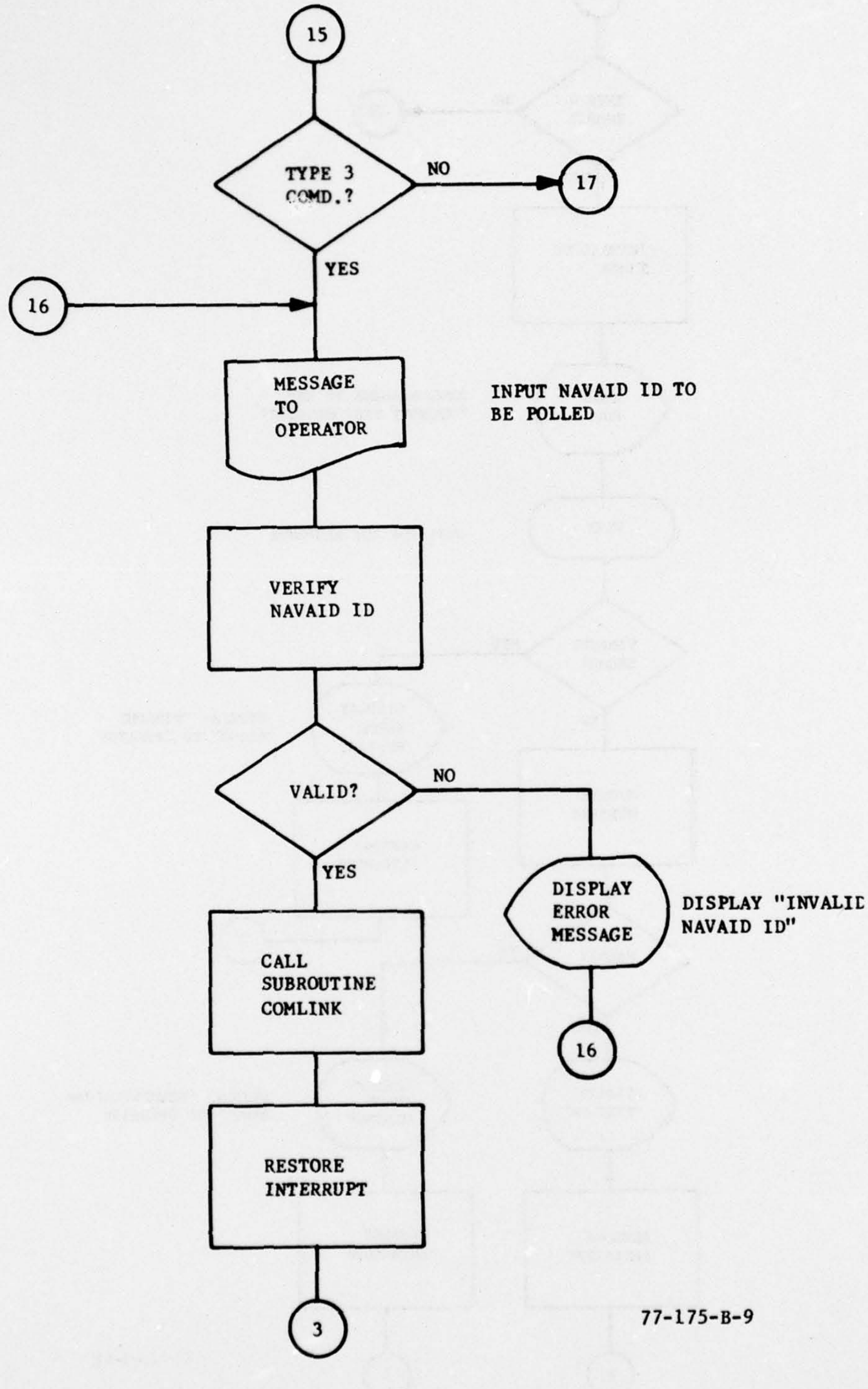

7
WAIT
WAIT FOR RESPONSE FROM RDP
TIME OUT ERROR?
YES
NO
DISPLAY MSG
DISPLAY TIMEOUT ERROR MESSAGE
8
DECODE MESSAGE
MESSAGE GARBLED?
NO
9
8
YES
BUMP RETRY COUNTER
MAX RETRY?
NO
YES
SEND MSG
REPEAT LAST COMMAND
6
ERROR MESSAGE TO OPERATOR
9
RETURN
77-175-B-5


ENTER ON PRIORITY 3 INTERRUPT
10
DECODE COMMAND
TYPE 1 COMD.?
NO
13
YES
11
MESSAGE TO OPERATOR
REQUEST NAVAID ID AND (GO-NOGO) STATUS
ACCEPT INPUT
VERIFY NAVAID ID
VALID?
NO
YES
UPDATE POLLING SCHEDULER
DISPLAY MESSAGE
DISPLAY "INVALID NAVAID ID"
SEND MSG
11
SEND MESSAGE TO RDP TO RESET FLAG THAT INHIBITS DATA XMISSION (SEE COMMAND 3 OF RDP FLOWCHART)
CALL ROUTINE ACKNLDG
12

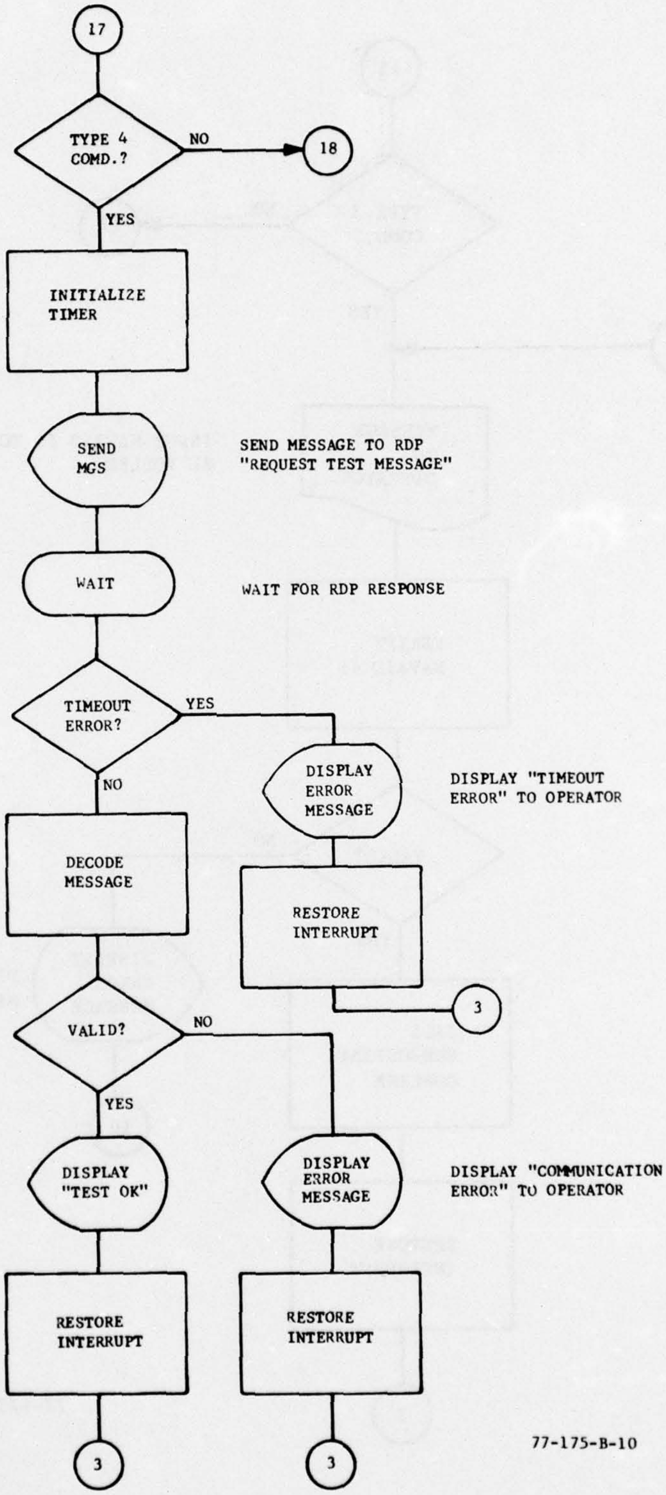
77-175-B-6

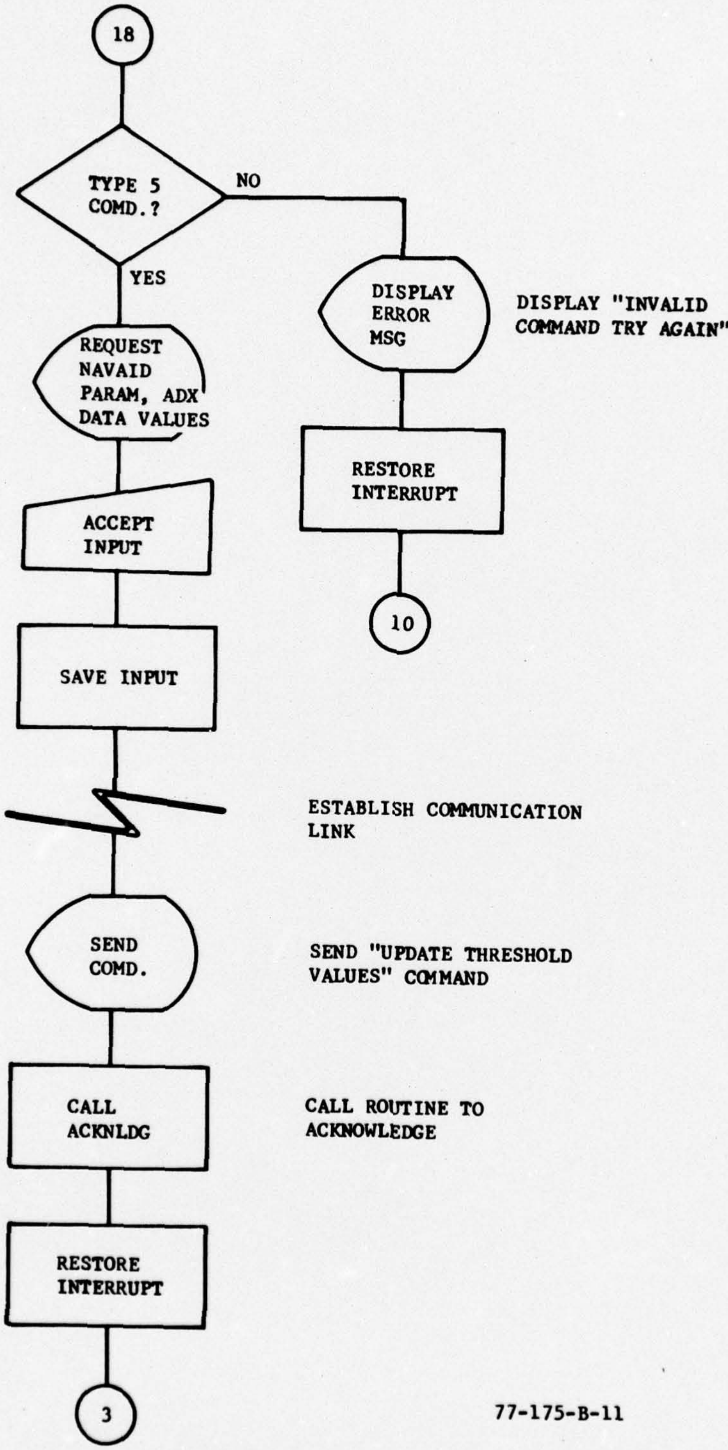

SUBROUTINE ACKNLDGE
INITIALIZE RETRY COUNTER
120
INITIALIZE TIMER
WAIT
WAIT FOR RDP RESPONSE
TIMEOUT ERROR
NO
RETURN
ASSUME RECEIPT OF ACKNOWLEDGE
YES
BUMP RETRY COUNTER
MAX RETRY
NO
SEND MSG
REPEAT LAST COMMAND
120
YES
ERROR MSG TO OPERATOR
"COMMUNICATION ERROR"
RESTORE INTERRUPT
3
77-175-B-7


12
LAST INPUT
NO
11
YES
RESTORE INTERRUPT
3
13
TYPE 2 COMD.?
NO
15
YES
14
MESSAGE TO OPERATOR
GIVE POLLING ORDER REQUEST
1) NAVAID POLLING SEQUENCE
2) TIME BETWEEN POLLING CYCLE
ACCEPT INPUT
BUILD SCHEDULER
BUILD POLLING SCHEDULER
BY SEQUENCE
LAST NAVAID?
NO
14
YES
RESTORE INTERRUPT
3
77-175-B-8


15
TYPE 3
COMD.?
NO
17
YES
16
MESSAGE
TO
OPERATOR
INPUT NAVAID ID TO
BE POLLED
VERIFY
NAVAID ID
VALID?
NO
YES
DISPLAY
ERROR
MESSAGE
DISPLAY "INVALID
NAVAID ID"
CALL
SUBROUTINE
COMLINK
16
RESTORE
INTERRUPT
3

77-175-B-9


17
TYPE 4 COMD.?
NO
18
YES
INITIALIZE TIMER
SEND MGS
SEND MESSAGE TO RDP "REQUEST TEST MESSAGE"
WAIT
WAIT FOR RDP RESPONSE
TIMEOUT ERROR?
YES
NO
DISPLAY ERROR MESSAGE
DISPLAY "TIMEOUT ERROR" TO OPERATOR
DECODE MESSAGE
RESTORE INTERRUPT
3
VALID?
NO
YES
DISPLAY "TEST OK"
DISPLAY ERROR MESSAGE
DISPLAY "COMMUNICATION ERROR" TO OPERATOR
RESTORE INTERRUPT
RESTORE INTERRUPT
3
3
77-175-B-10


18
TYPE 5 COMD.?
NO
YES
DISPLAY ERROR MSG
DISPLAY "INVALID COMMAND TRY AGAIN"
RESTORE INTERRUPT
10
REQUEST NAVAID PARAM, ADX DATA VALUES
ACCEPT INPUT
SAVE INPUT
ESTABLISH COMMUNICATION LINK
SEND COMD.
SEND "UPDATE THRESHOLD VALUES" COMMAND
CALL ACKNLDG
CALL ROUTINE TO ACKNOWLEDGE
RESTORE INTERRUPT
3

77-175-B-11